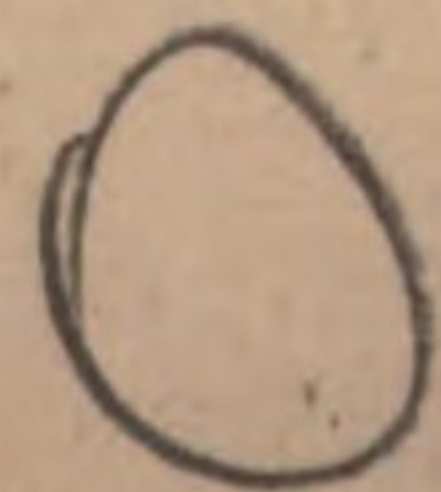


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S T R

STRENGTH OF MATERIALS, in mechanics, is a subject of so much importance, that in a nation so eminent as this for invention and ingenuity in all species of manufactures, and in particular so distinguished for its improvements in machinery of every kind, it is somewhat singular that no writer has treated it in the detail which its importance and difficulty demands. The man of science who visits our great manufactures is delighted with the ingenuity which he observes in every part, the innumerable inventions which come even from individual artisans, and the determined purpose of improvement and refinement which he sees in every workshop. Every cotton mill appears an academy of mechanical science; and mechanical invention is spreading from these fountains over the whole kingdom: But the philosopher is mortified to see this ardent spirit so cramped by ignorance of principle, and many of these original and brilliant thoughts obscured and clogged with needless and even hurtful additions, and a complication of machinery which checks improvement even by its appearance of ingenuity. There is nothing in which this want of scientific education, this ignorance of principle, is so frequently observed as in the injudicious proportion of the parts of machines and other mechanical structures; proportions and forms of parts in which the strength and position are nowise regulated by the strains to which they are exposed, and where repeated failures have been the only lessons.

It cannot be otherwise. We have no means of instruction, except two very short and abstracted treatises of the late Mr Emerson on the strength of materials. We do not recollect a performance in our language from which our artists can get information. Treatises written expressly on different branches of mechanical arts are totally silent on this, which is the basis and *only principle* of their performances. Who would imagine that PRICE'S BRITISH CARPENTER, the work of the first reputation in this country, and of which the sole aim is to teach the carpenter to erect solid and durable structures, does not contain one proposition or one reason by which one form of a thing can be shown to be stronger or weaker than another? We doubt very much if one carpenter in an hundred can give a reason to convince his own mind that a joist is stronger when laid on its edge than when laid on its broad side. We speak in this strong manner in hopes of exciting some man of science to publish a system of instruction on this subject. The limits of our Work will not admit of a detail: but we think it necessary to point out the leading principles, and to give the traces of that systematic connection by which all the knowledge already possessed of this subject may be brought together and properly arranged. This we shall now attempt in as brief a manner as we are able.

THE strength of materials arises immediately or ultimately from the cohesion of the parts of bodies. Our examination
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tion of this property of tangible matter has as yet been very partial and imperfect, and by no means enables us to apply mathematical calculations with precision and success. The various modifications of cohesion, in its different appearances of perfect softness, plasticity, ductility, elasticity, hardness, have a mighty influence on the strength of bodies, but are hardly susceptible of measurement. Their texture also, whether uniform like glass and ductile metals, crystallized or granulated like other metals and freestone, or fibrous like timber, is a circumstance no less important; yet even here, although we derive some advantage from remarking to which of these forms of aggregation a substance belongs, the aid is but small. All we can do in this want of general principles is to make experiments on every class of bodies. Accordingly philosophers have endeavoured to instruct the public in this particular. The Royal Society of London at its very first institution made many experiments at their meetings, as may be seen in the first registers of the Society. † See Birche's History, and Hooke's Mathematical Collections. Several individuals have added their experiments. The most numerous collection in detail is by Muschenbroek, professor of natural philosophy at Leyden. Part of it was published by himself in his *Essais de Physique*, in 2 vols 4to; but the full collection is to be found in his *System of Natural Philosophy*, published after his death by Lulofs, in 3 vols 4to. This was translated from the Low Dutch into French by Sigaud de la Fond, and published at Paris in 1760, and is a prodigious collection of physical knowledge of all kinds, and may almost suffice for a library of natural philosophy. But this collection of experiments on the cohesion of bodies is not of that value which one expects. We presume that they were carefully made and faithfully narrated; but they were made on such small specimens that the unavoidable natural inequalities of growth or texture produced irregularities in the results which bore too great a proportion to the whole quantities observed. We may make the same remark on the experiments of Couplet, Pitot, De la Hire, Du Hamel, and others of the French academy. In short, if we except the experiments of Buffon on the strength of timber, made at the public expence on a large scale, there is nothing to be met with from which we can obtain absolute measures which may be employed with confidence; and there is nothing in the English language except a simple list by Emerson, which is merely a set of affirmations, without any narration of circumstances, to enable us to judge of the validity of his conclusions; but the character of Mr Emerson, as a man of knowledge and of integrity, gives even to these assertions a considerable value.

But to make use of any experiments, there must be employed some general principle by which we can generalize their results. They will otherwise be only narrations of detached facts. We must have some notion of that intermedium, by the intervention of which an external force applied to one part of a lever, joist, or pillar, occasions a strain on a distant part. This can be nothing but the cohesion between the parts.

GMBM

Strength of
Materials.
5
Strength
defined.

parts. It is this connecting force which is brought into action, or, as we more shortly express it, excited. This action is modified in every part by the laws of mechanics. It is this action which is what we call the *strength* of that part, and its effect is the strain on the adjoining parts; and thus it is the same force, differently viewed, that constitutes both the strain and the strength. When we consider it in the light of a resistance to fracture, we call it *strength*.

6
Causes
known on-
ly from
their ef-
fects.

We call every thing a *force* which we observe to be ever accompanied by a change of motion; or, more strictly speaking, we infer the presence and agency of a force wherever we observe the state of things in respect of motion different from what we know to be the result of the action of all the forces which we know to act on the body. Thus when we observe a rope prevent a body from falling, we infer a moving force inherent in the rope with as much confidence as when we observe it drag the body along the ground. The *immediate* action of this force is undoubtedly exerted between the immediately adjoining parts of the rope. The immediate effect is the keeping the particles of the rope together. They ought to separate by any external force drawing the ends of the rope contrarywise; and we ascribe their not doing so to a mechanical force really opposing this external force. When desired to give it a name, we name it from what we conceive to be its effect, and therefore its characteristic, and we call it *COHESION*. This is merely a name for the fact; but it is the same thing in all our denominations. We know nothing of the causes but in the effects; and our name for the cause is in fact the name of the effect, which is *COHESION*. We mean nothing else by gravitation or magnetism. What do we mean when we say that Newton understood thoroughly the nature of gravitation, of the force of gravitation; or that Franklin understood the nature of the electric force? Nothing but this: Newton considered with patient sagacity the general facts of gravitation, and has described and classed them with the utmost precision. In like manner, we shall understand the nature of cohesion when we have discovered with equal generality the laws of cohesion, or general facts which are observed in the appearances, and when we have described and classed them with equal accuracy.

Let us therefore attend to the more simple and obvious phenomena of cohesion, and mark with care every circumstance of resemblance by which they may be classed. Let us receive these as the laws of cohesion, characteristic of its supposed cause, the force of cohesion. We cannot pretend to enter on this vast research. The modifications are innumerable; and it would require the penetration of more than Newton to detect the circumstance of similarity amidst millions of discriminating circumstances. Yet this is the only way of discovering which are the primary facts characteristic of the force, and which are the modifications. The study is immense, but is by no means desperate; and we entertain great hopes that it will ere long be successfully prosecuted: but, in our particular predicament, we must content ourselves with selecting such general laws as seem to give us the most immediate information of the circumstances that must be attended to by the mechanic in his constructions, that he may unite strength with simplicity, economy, and energy.

7
All bodies
elastic.

1st, Then, it is a matter of fact that all bodies are in a certain degree perfectly elastic; that is, when their form or bulk is changed by certain moderate compressions or distractions, it requires the continuance of the changing force to continue the body in this new state; and when the force is removed, the body recovers its original form. We limit the assertion to *certain moderate* changes: For instance, take a lead wire of $\frac{1}{16}$ th of an inch in diameter and ten feet

long; fix one end firmly to the ceiling, and let the wire hang perpendicular; affix to the lower end an index like the hand of a watch; on some stand immediately below let there be a circle divided into degrees, with its centre corresponding to the lower point of the wire: now turn this index twice round, and thus twist the wire. When the index is let go, it will turn backwards again, by the wire's untwisting itself, and make almost four revolutions before it stops; after which it twists and untwists many times, the index going backwards and forwards round the circle, diminishing however its arch of twist each time, till at last it settles precisely in its original position. This may be repeated for ever. Now, in this motion, every part of the wire partakes equally of the twist. The particles are stretched, require force to keep them in their state of extension, and recover completely their original relative positions. These are all the characters of what the mechanician calls *perfect elasticity*. This is a quality quite familiar in many cases; as in glass, tempered steel, &c. but was thought incompetent to lead, which is generally considered as having little or no elasticity. But we make the assertion in the most general terms, with the limitation to moderate derangement of form. We have made the same experiment on a thread of pipe-clay, made by forcing soft clay through the small hole of a syringe by means of a screw; and we found it more elastic than the lead wire: for a thread of $\frac{1}{16}$ th of an inch diameter and 7 feet long allowed the index to make two turns, and yet completely recovered its first position.

2^{dly}, But if we turn the index of the lead wire four times round, and let it go again, it untwists again in the same manner, but it makes little more than four turns back again; and after many oscillations it finally stops in a position almost two revolutions removed from its original position. It has now acquired a new arrangement of parts, and this new arrangement is permanent like the former; and, what is of particular moment, it is perfectly elastic. This change is familiarly known by the denomination of a *SET*. The wire is said to have *TAKEN A SET*. When we attend minutely to the procedure of nature in this phenomenon, we find that the particles have as it were slid on each other, still cohering, and have taken a new position, in which their connecting forces are in equilibrium: and in this change of relative situation, it appears that the connecting forces which maintained the particles in their first situations were not in equilibrium in some position intermediate between that of the first and that of the last form. The force required for changing this first form augmented with the change, but only to a certain degree; and during this process the connecting forces always tended to the recovery of this first form. But after the change of mutual position has passed a certain magnitude, the union has been partly destroyed, and the particles have been brought into new situations; such, that the forces which now connect each with its neighbour tend, not to the recovery of the first arrangement, but to push them farther from it, into a new situation, to which they now verge, and require force to prevent them from acquiring. The wire is now in fact again perfectly elastic; that is, the forces which now connect the particles with their new neighbours augment to a certain degree as the derangement from this new position augments. This is not reasoning from any theory. It is narrating facts, on which a theory is to be founded. What we have been just now saying is evidently a description of that sensible form of tangible matter which we call *ductility*. It has every gradation of variety, from the softness of butter to the firmness of gold. All these bodies have some elasticity; but we say they are not perfectly elastic, because they do not completely recover their original form when it has been greatly

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Materials.

8
What is
meant by
a *set*.

9
Ductility.

⁹ Strength of Materials. ¹⁰ Viscidity. ¹¹ Observed in all homogeneous plastic bodies.

greatly deranged. The whole gradation may be most distinctly observed in a piece of glass or hard sealing-wax. In the ordinary form glass is perhaps the most completely elastic body that we know, and may be bent till just ready to snap, and yet completely recovers its first form, and takes no set whatever; but when heated to such a degree as just to be visible in the dark, it loses its brittleness, and becomes so tough that it cannot be broken by any blow; but it is no longer elastic, takes any set, and keeps it. When more heated, it becomes as plastic as clay; but in this state is remarkably distinguished from clay by a quality which we may call VISCIDITY, which is something like elasticity, of which clay and other bodies purely plastic exhibit no appearance. This is the joint operation of strong adhesion and softness. When a rod of perfectly soft glass is suddenly stretched a little, it does not at once take the shape which it acquires after some little time. It is owing to this, that in taking the impression of a seal, if we take off the seal while the wax is yet very hot, the sharpness of the impression is destroyed immediately. Each part drawing its neighbour, and each part yielding, the prominent parts are pulled down and blunted, and the sharp hollows are pulled upwards and also blunted. The seal must be kept on till all has become not only stiff but hard.

This viscosity is to be observed in all plastic bodies which are homogeneous. It is not observed in clay, because it is not homogeneous, but consists of hard particles of the argillaceous earth sticking together by their attraction for water. Something like it might be made of finely powdered glass and a clammy fluid such as turpentine. Viscidity has all degrees of softness till it degenerates to ropy fluidity like that of olive oil. Perhaps something of it may be found even in the most perfect fluid that we are acquainted with, as we observed in the experiments for ascertaining specific gravity.

There is in a late volume of the Philosophical Transactions a narration of experiments, by which it appears that the thread of the spider is an exception to our first general law, and that it is perfectly ductile. It is there asserted, that a long thread of gossamer, furnished with an index, takes any position whatever; and that though the index be turned round any number of times (even many hundreds), it has no tendency to recover its first form. The thread takes completely any set whatever. We have not had an opportunity of repeating this experiment, but we have distinctly observed a phenomenon totally inconsistent with it. If a fibre of gossamer about an inch long be held by the end horizontally, it bends downward in a curve like a slender slip of whalebone or a hair. If totally devoid of elasticity, and perfectly indifferent to any set, it would hang down perpendicularly without any curvature.

When ductility and elasticity are combined in different proportions, an immense variety of sensible modes of aggregation may be produced. Some degree of both are probably to be observed in all bodies of complex constitution; that is, which consist of particles made up of many different kinds of atoms. Such a constitution of a body must afford many situations permanent, but easily deranged.

In all these changes of disposition which take place among the particles of a ductile body, the particles are at such distance that they still cohere. The body may be stretched a little; and on removing the extending force, the body shrinks into its first form. It also resists moderate compressions; and when the compressing force is removed, the body swells out again. Now the corpuscular fact here is, that the particles are acted on by attractions and repulsions, which balance each other when no external force is acting on the body, and which augment as the particles are made,

by any external cause, to recede from this situation of mutual inactivity; for since force is requisite to produce either the dilatation or the compression, and to maintain it, we are obliged, by the constitution of our minds, to infer that it is opposed by a force accompanying or inherent in every particle of dilatable or compressible matter; and as this necessity of employing force to produce a change indicates the agency of these corpuscular forces, and marks their kind, according as the tendencies of the particles appear to be toward each other in dilatation, or from each other in compression; so it also measures the degrees of their intensity. Should it require three times the force to produce a double compression, we must reckon the mutual repulsions triple when the compression is doubled; and so in other instances. We see from all this that the phenomena of cohesion indicate some relation between the intensity of the force of cohesion and the distance between the centres of the particles. To discover this relation is the great problem in corpuscular mechanism, as it was in the Newtonian investigation of the force of gravitation. Could we discover this law of action between the corpuscles with the same certainty and distinctness, we might with equal confidence say what will be the result of any position which we give to the particles of bodies; but this is beyond our hopes. The law of gravitation is so simple that the discovery or detection of it amid the variety of celestial phenomena required but one step; and in its own nature its possible combinations still do not greatly exceed the powers of human research. One is almost disposed to say that the Supreme Being has exhibited it to our reasoning powers as sufficient to employ with success our utmost efforts, but not so abstruse as to discourage us from the noble attempt. It seems to be otherwise with respect to cohesion. Mathematics informs us, that if it deviates sensibly from the law of gravitation, the simplest combinations will make the joint action of several particles an almost impenetrable mystery. We must therefore content ourselves, for a long while to come, with a careful observation of the simplest cases that we can propose, and with the discovery of secondary laws of action, in which many particles combine their influence. In pursuance of this plan, we observe,

3^{dly}, That whatever is the situation of the particles of a body with respect to each other, when in a quiescent state, they are kept in these situations by the balance of opposite forces. This cannot be refused, nor can we form to ourselves any other notion of the state of the particles of a body. Whether we suppose the ultimate particles to be of certain magnitudes and shapes, touching each other in single points of cohesion; or whether we (with Bosovich) consider them as at a distance from each other, and acting on each other by attractions and repulsions—we must acknowledge, in the first place, that the centres of the particles (by whose mutual distances we must estimate the distance of the particles) may and do vary their distances from each other. What else can we say when we observe a body increase in length, in breadth, and in thickness, by heating it, or when we see it diminish in all these dimensions by an external compression? A particle, therefore, situated in the midst of many others, and remaining in that situation, must be conceived as maintained in it by the mutual balancing of all the forces which connect it with its neighbours. It is like a ball kept in its place by the opposite action of two springs. This illustration merits a more particular application. Suppose a number of balls ranged on the table in the angles of equilateral triangles, and that each ball is connected with the six which lie around it by means of an elastic wire curled like a cork-screw; suppose such another stratum of balls above this, and parallel to it, and so placed that

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Materials.

each ball of the upper stratum is perpendicularly over the centre of the equilateral triangle below, and let these be connected with the balls of the under stratum by similar spiral wires. Let there be a third and a fourth, and any number of such strata, all connected in the same manner. It is plain that this may extend to any size and fill any space.—Now let this assemblage of balls be firmly contemplated by the imagination, and be supposed to shrink continually in all its dimensions, till the balls, and their distances from each other, and the connecting wires, all vanish from the sight as discrete individual objects. All this is very conceivable. It will now appear like a solid body, having length, breadth, and thickness; it may be compressed, and will again resume its dimensions; it may be stretched, and will again shrink; it will move away when struck; in short, it will not differ in its sensible appearance from a solid elastic body. Now when this body is in a state of compression, for instance, it is evident that any one of the balls is at rest, in consequence of the mutual balancing of the actions of all the spiral wires which connect it with those around it. It will greatly conduce to the full understanding of all that follows to recur to this illustration. The analogy or resemblance between the effects of this constitution of things and the effects of the corpuscular forces is very great; and wherever it obtains, we may safely draw conclusions from what we know would be the condition of the balls in particular circumstances to what will be the condition of a body of common tangible matter. We shall just give one instructive example, and then have done with this hypothetical body. We can suppose it of a long shape, resting on one point; we can suppose two weights A, B, suspended at the extremities, and the whole in equilibrio. We commonly express this state of things by saying that A and B are in equilibrio. This is very inaccurate. A is in fact in equilibrio with the united action of all the springs which connect the ball to which it is applied with the adjoining balls. These springs are brought into action, and each is in equilibrio with the joint action of all the rest. Thus through the whole extent of the hypothetical body, the springs are brought into action in a way and in a degree which mathematics can easily investigate. We need not do this: it is enough for our purpose that our imagination readily discovers that some springs are stretched, others are compressed, and that a pressure is excited on the middle point of support, and the support exerts a reaction which precisely balances it; and the other weight is, in like manner, in immediate equilibrio with the equivalent of the actions of all the springs which connect the last ball with its neighbours. Now take the analogical or resembling case, an oblong piece of solid matter, resting on a fulcrum, and loaded with two weights in equilibrio. For the actions of the connecting springs substitute the corpuscular forces, and the result will resemble that of the hypothesis.

Now as there is something that is at least analogous to a change of distance of the particles, and a concomitant change of the intensity of the connecting forces, we may express this in the same way that we are accustomed to do in similar cases. Let A and B (fig. 1.) represent the centres of two particles of a coherent elastic body in their quiescent inactive state, and let us consider only the mechanical condition of B. The body may be stretched. In this case the distance A B of the particles may become A C. In this state there is something which makes it necessary to employ a force to keep the particles at this distance. C has a tendency towards A, or we may say that A attracts C. We may represent the magnitude of this tendency of C towards A, or this attraction of A, by a line C c perpendicular to A C. Again, the body may be compressed, and the

distance A B may become A D. Something obliges us to employ force to continue this compression; and D tends from A, or A appears to *repel* D. The intensity of this tendency or repulsion may be represented by another perpendicular D d; and, to represent the different directions of these tendencies, or the different nature of these actions, we may set D d on the opposite side of A B. It is in this manner that the Abbé Boscovich has represented the actions of corpuscular forces in his celebrated Theory of Natural Philosophy. Newton had said, that, as the great movements of the solar system were regulated by forces operating at a distance and varying with the distance, so he strongly suspected (*valde suspicor*) that all the phenomena of cohesion, with all its modifications in the different sensible forms of aggregation, and in the phenomena of chemistry and physiology, resulted from the similar agency of forces varying with the distance of the particles. The learned Jesuit pursued this thought; and has shown, that if we suppose an ultimate atom of matter endowed with powers of attraction and repulsion, varying, both in kind and degree, with the distance, and if this force be the same in every atom, it may be regulated by such a relation to the distance from the neighbouring atom, that a collection of such atoms may have all the sensible appearances of bodies in their different forms of solids, liquids, and vapours, elastic or unelastic, and endowed with all the properties which we perceive, by whose immediate operation the phenomena of motion by impulse, and all the phenomena of chemistry, and of animal and vegetable economy, may be produced. He shows, that notwithstanding a perfect sameness, and even a great simplicity in this atomical constitution, there will result from this union all that unspeakable variety of form and property which diversify and embellish the face of nature. We shall take another opportunity of giving such an account of this celebrated work as it deserves. We mention it only, by the by, as far as a general notion of it will be of some service on the present occasion. For this purpose, we just observe that Boscovich conceives a particle of any individual species of matter to consist of an unknown number of particles of simpler constitution; each of which particles, in their turn, is compounded of particles still more simply constituted, and so on through an unknown number of orders, till we arrive at the simplest possible constitution of a particle of tangible matter, susceptible of length, breadth, and thickness, and necessarily consisting of four atoms of matter. And he shows that the more complex we suppose the constitution of a particle, the more must the sensible qualities of the aggregate resemble the observed qualities of tangible bodies. In particular, he shows how a particle may be so constituted, that although it act on one other particle of the same kind through a considerable interval, the interposition of a third particle of the same kind may render it totally, or almost totally, inactive; and therefore an assemblage of such particles would form such a fluid as air. All these curious inferences are made with uncontrovertible evidence; and the greatest encouragement is thus given to the mathematical philosopher to hope, that by cautious and patient proceeding in this way, we may gradually approach to a knowledge of the laws of cohesion, that will not shun a comparison even with the *Principia* of Newton. No step can be made in this investigation, but by observing with care, and generalizing with judgment, the phenomena, which are abundantly numerous, and much more at our command than those of the great and sensible motions of bodies. Following this plan, we observe,

4thly, It is matter of fact, that every body has some degree of compressibility and dilatibility; and when the changes of dimension are so moderate that the body completely recovers its

Strength of
Materials.17
How Bos-
covich re-
presents the
action of
corpuscular
forces.16
By exam-
ple.

Plate

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18

Every bo-
dy com-
pressible
and dila-
table.

Strength of Materials. 19
 Law of nature discovered by Dr Hooke, its original dimensions on the cessation of the changing force, the extensions or compressions are sensibly proportional to the extending or compressing forces; and therefore the connecting forces are proportional to the distances of the particles from their quiescent, neutral, or inactive positions. This seems to have been first viewed as a law of nature by the penetrating eye of Dr Robert Hooke, one of the most eminent philosophers of the last century. He published a cipher, which he said contained the theory of springiness and of the motions of bodies by the action of springs. It was this, *ccii inosssttuu*.—When explained in his dissertation, published some years after, it was *ut tensio sic vis*. This is precisely the proposition just now asserted as a general fact, a law of nature. This dissertation is full of curious observations of facts in support of his assertion. In his application to the motion of bodies he gives his noble discovery of the balance-spring of a watch, which is founded on this law. The spring, as it is more and more coiled up, or unwound, by the motion of the balance, acts on it with a force proportional to the distance of the balance from its quiescent position. The balance therefore is acted on by an accelerating force, which varies in the same manner as the force of gravity acting on a pendulum swinging in a cycloid. Its vibrations therefore must be performed in equal time, whether they are wide or narrow. In the same dissertation Hooke mentions all the facts which John Bernoulli afterwards adduced in support of Leibnitz's whimsical doctrine of the force of bodies in motion, or the doctrine of the *vires vivæ*; a doctrine which Hooke might justly have claimed as his own, had he not seen its futility.

20
 And confirmed by the experiments of others.

Experiments made since the time of Hooke show that this law is strictly true in the extent to which we have limited it, viz. in all the changes of form which will be completely undone by the elasticity of the body. It is nearly true to a much greater extent. James Bernoulli, in his dissertation on the elastic curve, relates some experiments of his own, which seem to deviate considerably from it; but on close examination they do not. The finest experiments are those of Coulomb, published in some late volumes of the memoirs of the Academy of Paris. He suspended balls by wires, and observed their motions of oscillation, which he found accurately corresponding with this law.

This we shall find to be a very important fact in the doctrine of the strength of bodies, and we desire the reader to make it familiar to his mind. If we apply to this our manner of expressing these forces by perpendicular ordinates *Cc*, *Dd* (fig. 1.), we must take other situations *E*, *F*, of the particle *B*, and draw *Ee*, *Ff*; and we must have $DD : Ff = BD : BF$, or $Cc : Ee = BC : BE$. In such a supposition *Fd Bce* must be a straight line. But we shall have abundant evidence by and by that this cannot be strictly true, and that the line *Bce* which limits the ordinates expressing the attractive forces becomes concave towards the line *ABE*, and that the part *Bdf* is convex towards it. All that can be safely concluded from the experiments hitherto made is, that to a certain extent the forces, both attractive and repulsive, are sensibly proportional to the dilatations and compressions. For,

21
 When a body is much dilated, a small addition of force will increase its dilatation.

5thly, It is universally observed, that when the dilatations have proceeded a certain length, a less addition of force is sufficient to increase the dilatation in the same degree. This is always observed when the body has been so far stretched that it takes a set, and does not completely recover its form. The like may be generally observed in compressions. Most persons will recollect, that in violently stretching an elastic cord, it becomes suddenly weaker, or more easily stretched. But these phenomena do not positively prove a diminution of the corpuscular force acting on one particle: It more

probably arises from the disunion of some particles, whose Strength of Materials. action contributed to the whole or sensible effect. And in compressions we may suppose something of the same kind; for when we compress a body in one direction, it commonly bulges out in another; and in cases of very violent action some particles may be disunited, whose transverse action had formerly balanced part of the compressing force. For the reader will see on reflection, that since the compression in one direction causes the body to bulge out in the transverse direction; and since this bulging out is in opposition to the transverse forces of attraction, it must employ some part of the compressing force. And the common appearances are in perfect uniformity with this conception of things. When we press a bit of dryish clay, it swells out and cracks transversely. When a pillar of wood is overloaded, it swells out, and small crevices appear in the direction of the fibres. After this it will not bear half of the load. This the carpenters call CRIPPLING; and a knowledge of the circumstances which modify it is of great importance, and enables us to understand some very paradoxical appearances, as will be shown by and by.

This partial disuniting of particles formerly cohering is, we imagine, the chief reason why the totality of the forces which really oppose an external strain does not increase in the proportion of the extensions and compressions. But sufficient evidence will also be given that the forces which would connect one particle with one other particle do not augment in the accurate proportion of the change of distance; that in extensions they increase more slowly, and in compressions more rapidly.

But there is another cause of this deviation perhaps equal- Ductility 22 ly effectual with the former. Most bodies manifest some degree of ductility. Now what is this? The fact is, that the parts have taken a new arrangement, in which they again cohere. Therefore, in the passage to this new arrangement, the sensible forces, which are the joint result of many corpuscular forces, begin to respect this new arrangement instead of the former. This must change the simple law of corpuscular force, characteristic of the particular species of matter under examination. It does not require much reflection to convince us that the possible arrangements which the particles of a body may acquire, without appearing to change their nature, must be more numerous according as the particles are of a more complex constitution; and it is reasonable to suppose that the constitution even of the most simple kind of matter that we are acquainted with is exceedingly complex. Our microscopes show us animals so minute, that a heap of them must appear to the naked eye an uniform mass with a grain finer than that of the finest marble or razor hone; and yet each of these has not only limbs, but bones, muscular fibres, blood-vessels, fibres, and a blood consisting, in all probability, of globules organised and complex like our own. The imagination is here lost in wonder; and nothing is left us but to adore inconceivable art and wisdom, and to exult in the thought that we are the only spectators of this beautiful scene who can derive pleasure from the view. What is trodden under foot with indifference, even by the half-reasoning elephant, may be made by us the source of the purest and most unmixed pleasure. But let us proceed to observe,

6thly, That the forces which connect the particles of tan- 23 gible bodies change by a change of distance, not only in degree, but also in kind. The particle *B* (fig. 1.) is attracted by *A* when in the situation *C* or *E*. It is repelled by it when at *D* or *F*. It is not affected by it when in the situation *B*. The reader is requested carefully to remark, that this is not an inference founded on the authority of our mathematical figure. The figure is an expression (to assist the imagination) of facts in nature. It requires no force to keep the particles of a body in their

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Materials.

Strength of their quiescent situations: but if they are separated by stretching the body, they endeavour (pardon the figurative expression) to come together again. If they are brought nearer by compression, they endeavour to recede. This endeavour is manifested by the necessity of employing force to maintain the extension or condensation; and we represent this by the different position of our lines. But this is not all: the particle B, which is repelled by A when in the situation F or D, is neutral when at B, and is attracted when at C or E, may be placed at such a distance A G from A greater than A B that it shall be again repelled, or at such a distance A H that it shall again be attracted; and these alterations may be repeated again and again. This is curious and important, and requires something more than a bare assertion for its proof.

24
Light alternately
attracted
and repelled.

In the article OPTICS we mentioned the most curious and valuable observations of Sir Isaac Newton, by which it appears that light is thus alternately attracted and repelled by bodies. The rings of colour which appear between the object glasses of long telescopes showed, that in the small interval of $\frac{1}{1000}$ th of an inch, there are at least an hundred such changes observable, and that it is highly probable that these alternations extend to a much greater distance. At one of these distances the light actually converges towards the solid matter of the glass, which we express shortly, by saying that it is attracted by it, and that at the next distance it declines from the glass, or is repelled by it. The same thing is more simply inferred from the phenomena of light passing by the edges of knives and other opaque bodies. We refer the reader to the experiments themselves, the detail being too long for this place; and we request the reader to consider them minutely and attentively, and to form distinct notions of the inferences drawn from them. And we desire it to be remarked, that although Sir Isaac, in his discussion, always considers light as a set of corpuscles moving in free space, and obeying the actions of external forces like any other matter, the particular conclusion in which we are just now interested does not at all depend on this notion of the nature of light. Should we, with Des Cartes or Huygens, suppose light to be the undulation of an elastic medium, the conclusion will be the same. The undulations at certain distances are disturbed by forces directed towards the body, and at a greater distance, the disturbing forces tend from the body.

25
The same
alternations
of attraction
and repulsion
observable
in the particles
of other bodies,
as
glass.

But the same alternations of attraction and repulsion may be observed between the particles of common matter. If we take a piece of very flat and well polished glass, such as are made for the horizon glasses of a good Hadley's quadrant, and if we wrap round it a fibre of silk as it comes from the cocoon, taking care that the fibre nowhere crosses another, and then press this pretty hard on such another piece of glass, it will lift it up and keep it suspended. The particles therefore of the one do most certainly attract those of the other, and this at a distance equal to the thickness of the silk fibre. This is nearly the limit; and it sometimes requires a considerable pressure to produce the effect. The pressure is effectual only by compressing the silk fibre, and thus diminishing the distance between the glass plates. This adhesion cannot be attributed to the pressure of the atmosphere, because there is nothing to hinder the air from insinuating itself between the plates, since they are separated by the silk. Besides, the experiment succeeds equally well under the receiver of an air-pump. This most valuable experiment was first made by Huygens, who reported it to the Royal Society. It is narrated in the Philosophical Transactions, n° 86.

Here then is an attraction acting, like gravity, at a distance. But take away the silk fibre, and try to make the

Strength of
Materials.

glasses touch each other, and we shall find a very great force necessary. By Newton's experiments it appears, that unless the prismatic colours begin to appear between the glasses, they are at least $\frac{1}{1000}$ th of an inch asunder or more. Now we know that a very considerable force is necessary for producing these colours, and that the more we press the glasses together the more rings of colours appear. It also appears from Newton's measures, that the difference of distance between the glasses where each of these colours appear is about the 89,000th part of an inch. We know farther, that when we have produced the last appearance of a greasy or pearly colour, and then augment the pressure, making it about a thousand pounds on the square inch, all colours vanish, and the two pieces of glass seem to make one transparent undistinguishable mass. They appear now to have no air between them, or to be in mathematical contact. But another fact shows this conclusion to be premature. The same circles of colours appear in the top of a soap bubble; and as it grows thinner at top, there appears an unreflecting spot in the middle. We have the greatest probability therefore that the perfect transparency in the middle of the two glasses does not arise from their being in contact, but because the thickness of air between them is too small in that place for the reflection of light. Nay, Newton expressly found no reflection where the thickness was $\frac{1}{2}$ ths or more of the $\frac{1}{1000}$ th part of an inch.

All this while the glasses are strongly repelling each other, for great pressure is necessary for continuing the appearance of those colours, and they vanish in succession as the pressure is diminished. This vanishing of the colours is a proof that the glasses are moving off from each other, or repelling each other. But we can put an end to this repulsion by very strong pressure, and at the same time sliding the glasses on each other. We do not pretend to account for this effect of the sliding motion; but the fact is, that by so doing, the glasses will cohere with very great force, so that we shall break them by any attempt to pull them asunder. It commonly happens (at least it did so with us), that in this sliding compression of two smooth flat plates of glass they scratch and mutually destroy each other's surface. It is also worth remarking, that different kinds of glass exhibit different properties in this respect. Flint glass will attract even though a silk fibre lies double between them, and they much more readily cohere by this sliding pressure.

Here then are two distances at which the plates of glass attract each other; namely, when the silk fibre is interposed, and when they are forced together with this sliding motion. And in any intermediate situation they repel each other. We see the same thing in other solid bodies. Two pieces of lead made perfectly clean, may be made to cohere by grinding them together in the same manner. It is in this way that pretty ornaments of silver are united to iron. The piece is scraped clean, and a small bit of silver like a fish scale is laid on. The die which is to strike it into a flower or other ornament is then set on it, and we give it a smart blow, which forces the metals into contact as firm as if they were soldered together. It sometimes happens that the die adheres to the coin so that they cannot be separated: and it is found that this frequently happens, when the engraving is such, that the raised figure is not completely surrounded with a smooth flat ground. The probable cause of this is curious. When the coin has a flat surface all around, this is produced by the most prominent part of the die. This applies to the metal, and completely confines the air which filled the hollow of the die. As the pressure goes on, the metal is squeezed up into the hollow of the die; but there is still air compressed between them, which cannot escape by any passage. It is therefore prodigiously condensed,

26
Lead and
iron.

27
Probable
cause
why the
die adheres
to the coin.

Strength of Materials. condensed, and exerts an elasticity proportioned to the condensation. This serves to separate the die from the metal when the stroke is over. The hollow part of the die has not touched the metal all the while, and we may say that the impression was made by air. If this air escape by any engraving reaching through the border, they cohere inseparably.

We have admitted that the glass plates are in contact when they cohere thus firmly. But we are not certain of this: for if we take these cohering glasses, and touch them with water, it quickly insinuates itself between them. Yet they still cohere, but can now be pretty easily separated.

28
Repulsion
the cause
of some bo-
dies swim-
ming in a
fluid spe-
cifically
lighter
than them-
selves.

It is owing to this repulsion, exerted through its proper sphere, that certain powders swim on the surface of water, and are wetted with great difficulty. Certain insects can run about on the surface of water. They have brushy feet, which occupy a considerable surface; and if their steps are viewed with a magnifying glass, the surface of the water is seen depressed all around, resembling the footsteps of a man walking on feather-beds. This is owing to a repulsion between the brush and the water. A common fly cannot walk in this manner on water. Its feet are wetted, because they attract the water instead of repelling it. A steel needle, wiped very clean, will lie on the surface of water, making an impression as a great bar would make on a feather bed; and its weight is less than that of the displaced water. A dew drop lies on the leaves of plants without touching them mathematically, as is plain from the extreme brilliancy of the reflection at the posterior surface; nay, it may be sometimes observed that the drops of rain lie on the surface of water, and roll about on it like balls on a table. Yet all these substances can be wetted; that is, water can be applied to them at such distances that they attract it.

What we said a little ago of water insinuating itself between the glass plates without altogether destroying their cohesion, shows that this cohesion is not the same that obtains between the particles of one of the plates; that is, the two plates are not in the state of one continued mass. It is highly probable, therefore, that between these two states there is an intermediate state of repulsion, nay, perhaps many such, alternated with attractive states.

A piece of ice is elastic, for it rebounds and it rings. Its particles, therefore, when compressed, refuse; and when stretched, contract again. The particles are therefore in the state represented by B in figure 1. acted on by repulsive forces, if brought nearer; and by attractive forces, if drawn further asunder. Ice expands, like all other bodies, by heat. It absorbs a vast quantity of fire; which, by combining its attractions and repulsions with those of the particles of ice, changes completely the law of action, without making any sensible change in the distance of the particles, and the ice becomes water. In this new state the particles are again in limits between attractive and repulsive forces; for water has been shown, by the experiments of Canton and Zimmerman, to be elastic or compressible. It again expands by heat. It again absorbs a prodigious quantity of heat, and becomes elastic vapour; its particles repelling each other at all distances yet observed. The distance between the particles of one plate of glass and those of another which lies on it, and is carried by it, is a distance of repulsion; for the force which supports the upper piece is acting in opposition to its weight. This distance is less than that at which it would suspend it below it with a silk fibre interposed; for no prismatic colours appear between them when the silk fibre is interposed. But the distance at which glass attracts water is much less than this, for no colours appear when glass is

wetted with water. This distance is less, and not greater, than the other; for when the glasses have water interposed between them instead of air, it is found, that when any particular colour appears, the thickness of the plate of water is to that of the plate of air which would produce the same colour nearly as 3 to 4. Now, if a piece of glass be wetted, and exhibit no colour, and another piece of glass be simply laid on it, no colour will appear; but if they are strongly pressed, the colours appear in the same manner as if the glasses had air between. Also, when glass is simply wetted, and the film of water is allowed to evaporate, when it is thus reduced to a proper thinness, the colours show themselves in great beauty.

These are a few of many thousand facts, by which it is unquestionably proved that the particles of tangible matter are connected by forces acting at a distance, varying with the distance, and alternately attractive and repulsive. If we represent these forces as we have already done in fig. 1. by the ordinates Cc, Dd, Ee, Ff, &c. of a curve, it is evident that this curve must cross the axis at all those distances where the forces change from attractive to repulsive, and the curve must have branches alternately above and below the axis.

All these alternations of attraction and repulsion take place at small and insensible distances. At all sensible distances the particles are influenced by the attraction of gravitation; and therefore this part of the curve must be a hyper-

bola whose equation is $y = \frac{a^3}{x^2}$. What is the form of

the curve corresponding to the smallest distance of the particles? that is, what is the mutual action between the particles just before their coming into absolute contact? Analogy should lead us to suppose it to be repulsion: for solidity is the last and simplest form of bodies with which we are acquainted.—Fluids are more compounded, containing fire as an essential ingredient. We should conclude that this ultimate repulsion is insuperable, for the hardest bodies are the most elastic. We are fully entitled to say, that this repelling force exceeds all that we have ever yet applied to overcome it; nay, there are good reasons for saying that this ultimate repulsion, by which the particles are kept from mathematical contact, is really insuperable in its own nature, and that it is impossible to produce mathematical contact.

We shall just mention one of these, which we consider as unanswerable. Suppose two atoms, or ultimate particles of matter A and B. Let A be at rest, and B move up to it with the velocity 2; and let us suppose that it comes into mathematical contact, and impels it (according to the common acceptance of the word). Both move with the velocity 1. This is granted by all to be the final result of the collision. Now the instant of time in which this communication happens is no part either of the duration of the solitary motion of A, nor of the joint motion of A and B: It is the separation or boundary between them. It is at once the end of the first, and the beginning of the second, belonging equally to both. A was moving with the velocity 2. The distinguishing circumstance therefore of its mechanical state is, that it has a determination (however incomprehensible) by which it would move for ever with the velocity 2, if nothing changed it. This it has during the whole of its solitary motion, and therefore in the last instant of this motion. In like manner, during the whole of the joint motion, and therefore in the first instant of this motion, the atom A has a determination by which it would move for ever with the velocity 1. In one and the same instant, therefore, the atom A has two incompatible determinations. Whatever notion we can form of this state, which

Strength of Materials.

29
Particles
of matter
connected
by forces
acting at a
distance.

30
Mathema-
tical con-
tact impos-
sible.

^{Strength of Materials.} Strength of which we call velocity, as a distinction of condition, the same impossibility of conception or the same absurdity occurs. Nor can it be avoided in any other way than by saying, that this change of A's motion is brought about by insensible gradations; that is, that A and B influence each other precisely as they would do if a slender spring were interposed. The reader is desired to look at what we have said in the article *PHYSICS*, § 82.

The two magnets there spoken of are good representatives of two atoms endowed with mutual powers of repulsion; and the communication of motion is accomplished in both cases in precisely the same manner.

If, therefore, we shall ever be so fortunate as to discover the law of variation of that force which connects one ATOM of matter with another atom, and which is therefore characteristic of matter, and the ultimate source of all its sensible qualities, the curve whose ordinates represent the kind and the intensity of this atomical force will be something like that sketched in fig. 2. The first branch *anB* will have *AK* (perpendicular to the axis *AH*) for its asymptote, and the last branch *lmo* will be to all sense a hyperbola, having *AO* for its asymptote; and the ordinates *lL, m M,*

&c. will be proportional to $\frac{1}{AL}, \frac{1}{AM},$ &c. expressing the universal gravitation of matter. It will have many branches *BbC, DdE, FfG,* &c. expressing attractions, and alternate repulsive branches *CcD, EeF, GgH,* &c. All these will be contained within a distance *AH*, which does not exceed a very minute fraction of an inch.

³¹
The simplest extended particle consists of four atoms.

The simplest particle which can be a constituent of a body having length, breadth, and thickness, must consist of four such atoms, all of which combine their influence on each atom of another such particle. It is evident that the curve which expresses the forces that connect two such particles must be totally different from this original curve, this hylarchic principle. Supposing the last known, our mathematical knowledge is quite able to discover the first; but when we proceed to compose a body of particles, each of which consists of four such particles, we may venture to say, that the compound force which connects them is almost beyond our search, and that the discovery of the primary force from an accurate knowledge of the corpuscular forces of this particular matter is absolutely out of our power.

All that we can learn is, the possibility, nay the certainty, of an innumerable variety of external sensible forms and qualities, by which different kinds of matter will be distinguished, arising from the number, the order of composition, and the arrangement of the subordinate particles of which a particle of this or that kind of matter is composed. All these varieties will take place at those small and insensible distances which are between *A* and *H*, and may produce all that variety which we observe in the tangible or mechanical forms of bodies, such as elasticity, ductility, hardness, softness, fluidity, vapour, and all those unseen motions or actions which we observe in fusion and congelation, evaporation and condensation, solution and precipitation, crystallization, vegetable and animal assimilation and secretion, &c. &c. &c. while all bodies must be, in a certain degree, elastic, all must gravitate, and all must be impenetrable.

This general and satisfactory resemblance between the appearances of tangible matter and the legitimate consequence of this general hypothetical property of an atom of matter, affords a considerable probability that such is the origin of all the phenomena. We earnestly recommend to our readers a careful perusal of *Boscovich's* celebrated treatise. A careful perusal is necessary for seeing its value; and

nothing will be got by a hasty look at it. The reader will be particularly pleased with the facility and evidence with which the ingenious author has deduced all the ordinary principles of mechanics, and with the explanation which he has given of fluidity, and his deduction from thence of the laws of hydrostatics. No part of the treatise is more valuable than the doctrine of the propagation of pressure through solid bodies. This, however, is but just touched on in the course of the investigation of the principles of mechanics. We shall borrow as much as will suffice for our present inquiry into the strength of materials; and we trust that our readers are not displeased with this general sketch of the doctrine (if it may be so called) of the cohesion of bodies. It is curious and important in itself, and is the foundation of all the knowledge we can acquire of the present article. We are sorry to say that it is as yet a new subject of study; but it is a very promising one, and we by no means despair of seeing the whole of chemistry brought by its means within the pale of mechanical science. The great and distinguishing agent in chemistry is heat, or fire the cause of heat; and one of its most singular effects is the conversion of bodies into elastic vapour. We have the clearest evidence that this is brought about by mechanical forces: for it can be opposed or prevented by external pressure, a very familiar mechanical force. We may perhaps find another mechanical force which will prevent fusion.

³²
The doctrine of cohesion yet a new subject.

HAVING now made our readers familiar with the mode of action in which cohesion operates in giving strength to solid bodies, we proceed to consider the strains to which this strength is opposed.

A piece of solid matter is exposed to four kinds of strain, pretty different in the manner of their operation.

1. It may be torn asunder, as in the case of ropes, stretch-ers, king-posts, tye-beams, &c.
2. It may be crushed, as in the case of pillars, posts, and truss-beams.
3. It may be broken across, as happens to a joist or lever of any kind.
4. It may be wrenched or twisted, as in the case of the axle of a wheel, the nail of a press, &c.

³³
Strains to which strength is opposed.

I. IT MAY BE PULLED ASUNDER.

This is the simplest of all strains, and the others are indeed modifications of it. To this the force of cohesion is directly opposed, with very little modification of its action by any particular circumstances.

³⁴
Matter may be pulled asunder.

When a long cylindrical or prismatic body, such as a rod of wood or metal, or a rope, is drawn by one end, it must be resisted at the other, in order to bring its cohesion into action. When it is fastened at one end, we cannot conceive it any other way than as equally stretched in all its parts; for all our observations and experiments on natural bodies concur in showing us that the forces which connect their particles, in any way whatever, are equal and opposite. This is called the *third law of motion*; and we admit its universality, while we affirm that it is purely experimental (see *PHYSICS*). Yet we have met with dissertations by persons of eminent knowledge, where propositions are maintained inconsistent with this. During the dispute about the communication of motion, some of the ablest writers have said, that a spring compressed or stretched at the two ends was gradually less and less compressed or stretched from the extremities towards the middle: but the same writers acknowledged the universal equality of action and reaction, which is quite incompatible with this state of the spring. No such inequality of compression or dilatation has ever been observed;

Strength of Materials. and a little reflection will show it to be impossible, in consistency with the equality of action and reaction.

Since all parts are thus equally stretched, it follows, that the strain in any transverse section is the same, as also in every point of that section. If therefore the body be supposed of a homogeneous texture, the cohesion of the parts is equable; and since every part is equally stretched, the particles are drawn to equal distances from their quiescent positions, and the forces which are thus excited, and now exerted in opposition to the straining force, are equal. This external force may be increased by degrees, which will gradually separate the part of the body more and more from each other, and the connecting forces increase with this increase of distance, till at last the cohesion of some particles is overcome. This must be immediately followed by a rupture, because the remaining forces are now weaker than before.

It is the united force of cohesion, immediately before the disunion of the first particles, that we call the **STRENGTH** of the section. It may also be properly called its **ABSOLUTE STRENGTH**, being exerted in the simplest form, and not modified by any relation to other circumstances.

35 A circumstance to be attended to in every construction requiring strength. If the external force has not produced any permanent change on the body, and it therefore recovers its former dimensions when the force is withdrawn, it is plain that this strain may be repeated as often as we please, and the body which withstands it once will always withstand it. It is evident that this should be attended to in all constructions, and that in all our investigations on this subject this should be kept strictly in view. When we treat a piece of soft clay in this manner, and with this precaution, the force employed must be very small. If we exceed this, we produce a permanent change. The rod of clay is not indeed torn asunder; but it has become somewhat more slender: the number of particles in a cross section is now smaller; and therefore, although it will again, in this new form, suffer, or allow an endless repetition of a certain strain without any farther permanent change, this strain is smaller than the former.

Something of the same kind happens in all bodies which receive a SETT by the strain to which they are exposed. All ductile bodies are of this kind. But there are many bodies which are not ductile. Such bodies break completely whenever they are stretched beyond the limit of their perfect elasticity. Bodies of a fibrous structure exhibit very great varieties in their cohesion. In some the fibres have no lateral cohesion, as in the case of a rope. The only way in which all the fibres can be made to unite their strength is, to twist them together. This causes them to bind each other so fast, that any one of them will break before it can be drawn out of the bundle. In other fibrous bodies, such as timber, the fibres are held together by some cement or gluten. This is seldom as strong as the fibre. Accordingly timber is much easier pulled asunder in a direction transverse to the fibres. There is, however, every possible variety in this particular.

36 Great varieties in cohesion, but In stretching and breaking fibrous bodies, the visible extension is frequently very considerable. This is not solely the increasing of the distance of the particles of the cohering fibre: the greatest part chiefly arises from drawing the crooked fibre straight. In this, too, there is great diversity; and it is accompanied with important differences in their power of withstanding a strain. In some woods, such as fir, the fibres on which the strength most depends are very straight. Such woods are commonly very elastic, do not take a sett, and break abruptly when overstrained: others, such as oak and birch, have their resisting fibres very undulating and crooked, and stretch very sensibly by a strain. They are very liable to take a set, and they do not break so

suddenly, but give warning by *complaining*, as the carpenters call it; that is, by giving visible signs of a derangement of texture. Hard bodies of an uniform glassy structure, or granulated like stones, are elastic through the whole extent of their cohesion, and take no sett, but break at once when overloaded.

Notwithstanding the immense variety which nature exhibits in the structure and cohesion of bodies, there are certain general facts of which we may now avail ourselves with advantage. In particular,

The absolute cohesion is proportional to the area of the section. This must be the case where the texture is perfectly uniform, as we have reason to think it is in glass and the ductile metals. The cohesion of each particle being alike, the whole cohesion must be proportional to their number, that is, to the area of the section. The same must be admitted with respect to bodies of a granulated texture, where the granulation is regular and uniform. The same must be admitted of fibrous bodies, if we suppose their fibres equally strong, equally dense, and similarly disposed through the whole section; and this we must either suppose, or must state the diversity, and measure the cohesion accordingly.

We may therefore assert, as a general proposition on this subject, that the absolute strength in any part of a body by which it resists being pulled asunder, or the force which must be employed to tear it asunder *in that part*, is proportional to the area of the section perpendicular to the extending force.

Therefore all cylindrical or prismatic rods are equally strong in every part, and will break alike in any part; and bodies which have unequal sections will always break in the slenderest part. The length of the cylinder or prism has no effect on the strength; and the vulgar notion, that it is easier to break a very long rope than a short one, is a very great mistake. Also the absolute strengths of bodies which have similar sections are proportional to the squares of their diameters or homologous sides of the section.

The weight of the body itself may be employed to strain it and to break it. It is evident, that a rope may be so long as to break by its own weight. When the rope is hanging perpendicularly, although it is equally strong in every part, it will break towards the upper end, because the strain on any part is the weight of all that is below it. Its **RELATIVE STRENGTH** in any part, or power of withstanding the strain which is actually laid on it, is inversely as the quantity below that part.

When the rope is stretched horizontally, as in towing a ship, the strain arising from its weight often bears a very sensible proportion to its whole strength.

Let AEB (fig. 3.) be any portion of such a rope, and AC, BC be tangents to the curve into which its gravity bends it. Complete the parallelogram ACBD. It is well known that the curve is a catenaria, and that DC is perpendicular to the horizon; and that DC is to AC as the weight of the rope AEB to the strain at A.

In order that a suspended heavy body may be equally able in every part to carry its own weight, the section in that part must be proportional to the solid contents of all that is below it. Suppose it a conoidal spindle, formed by the revolution of the curve Aae (fig. 4.) round the axis CE. We must have $AC^2 : ac^2 :: AEB \text{ sol.} : aEb \text{ sol.}$ This condition requires the logarithmic curve for Aae, of which Cc is the axis.

These are the chief general rules which can be safely deduced from our clearest notions of the cohesion of bodies. In order to make any practical use of them, it is proper to have some measures of the cohesion of such bodies as are

Strength of
Materials.

39

The cohe-
sion of me-
tals depends
on various
circumstan-
ces.

commonly employed in our mechanics, and other structures where they are exposed to this kind of strain. These must be deduced solely from experiment. Therefore they must be considered as no more than general values, or as the averages of many particular trials. The irregularities are very great, because none of the substances are constant in their texture and firmness. Metals differ by a thousand circumstances unknown to us, according to their purity, to the heat with which they were melted, to the moulds in which they were cast, and the treatment they have afterwards received, by forging, wire-drawing, tempering, &c.

It is a very curious and inexplicable fact, that by forging a metal, or by frequently drawing it through a smooth hole in a steel plate, its cohesion is greatly increased. This operation undoubtedly deranges the natural situation of the particles. They are squeezed closer together in one direction; but it is not in the direction in which they resist the fracture. In this direction they are rather separated to a greater distance. The general density, however, is augmented in all of them except lead, which grows rather rarer by wire-drawing: but its cohesion may be more than tripled by this operation. Gold, silver, and brass, have their cohesion nearly tripled; copper and iron have it more than doubled. In this operation they also grow much harder. It is proper to heat them to redness after drawing a little. This is called *nealing* or *annealing*. It softens the metal again, and renders it susceptible of another drawing without the risk of cracking in the operation.

We do not pretend to give any explanation of this remarkable and very important fact, which has something resembling it in woods and other fibrous bodies, as will be mentioned afterwards.

The varieties in the cohesion of stones and other minerals, and of vegetable and animal substances, are hardly susceptible of any description or classification.

40
Cohesion
and
strength
of different
metals.

We shall take for the measure of cohesion the number of pounds avoirdupois which are just sufficient to tear asunder a rod or bundle of one inch square. From this it will be easy to compute the strength corresponding to any other dimension.

1st, METALS.

		lbs.
Gold, cast	-	20,000
	-	24,000
Silver, cast	-	40,000
	-	43,000
Copper, cast	Japan	19,500
	Barbary	22,000
	Hungary	31,000
	Angelesea	34,000
	Sweden	37,000
Iron, cast	-	42,000
	-	59,000
Iron, bar	Ordinary	68,000
	Stirian	75,000
	Best Swedish and Russian	84,000
	Horse-nails	71,000 (A)
Steel, bar	Soft	120,000
	Razor temper	150,000
Tin, cast	Malacca	3,100
	Banca	3,600
	Block	3,800
	English block	5,200
	— grain	6,500

Lead, cast

lbs.

860

Regulus of antimony

1,000

Zinc

2,600

Bismuth

2,900

Strength of
Materials.41
Tenacity
of metals
increased by
mixture.

It is very remarkable that almost all the mixtures of metals are more tenacious than the metals themselves. The change of tenacity depends much on the proportion of the ingredients, and the proportion which produces the most tenacious mixture is different in the different metals. We have selected the following from the experiments of Muschenbroek. The proportion of ingredients here selected is that which produces the greatest strength.

Two parts of gold with one of silver	-	28,000
Five parts of gold with one of copper	-	50,000
Five parts of silver with one of copper	-	48,500
Four parts of silver with one of tin	-	41,000
Six parts of copper with one of tin	-	41,000
Five parts of Japan copper with one of Banca tin	-	57,000
Six parts of Chili copper with one of Malacca tin	-	60,000
Six parts of Swedish copper with one of Malacca tin	-	64,000
Brass consists of copper and zinc in an unknown proportion; its strength is	-	51,000
Three parts of block-tin with one part of lead	-	10,200
Eight parts of block-tin with one part of zinc	-	10,000
Four parts of Malacca tin with one part of regulus of antimony	-	12,000
Eight parts of lead with one of zinc	-	4,500
Four parts of tin with one of lead and one of zinc	-	13,000

These numbers are of considerable use in the arts. The mixtures of copper and tin are particularly interesting in the fabric of great guns. We see that, by mixing copper whose greatest strength does not exceed 37,000 with tin which does not exceed 6,000, we produce a metal whose tenacity is almost double, at the same time that it is harder and more easily wrought. It is, however, more fusible, which is a great inconvenience. We also see that a very small addition of zinc almost doubles the tenacity of tin, and increases the tenacity of lead five times; and a small addition of lead doubles the tenacity of tin. These are economical mixtures. This is a very valuable information to the plumbers for augmenting the strength of water-pipes.

By having recourse to these tables, the engineer can proportion the thickness of his pipes (of whatever metal) to the pressures to which they are exposed.

2^d, WOODS.

We may premise to this part of the table the following general observations:

1. The wood immediately surrounding the pith or heart of the tree is the weakest, and its inferiority is so much more remarkable as the tree is older. In this assertion, however, we speak with some hesitation. Muschenbroek's detail of experiments is decidedly in the affirmative. Mr Buffon, on the other hand, says, that his experience has taught him that the heart of a sound tree is the strongest; but he gives no instances. We are certain, from many observations

(A) This was an experiment by Muschenbroek, to examine the vulgar notion that iron forged from old horse-nails was stronger than all others, and shows its falsity.

Strength of Materials. Observations of our own on very large oaks and firs, that the heart is much weaker than the exterior parts.

2. The wood next the bark, commonly called the *white* or *blea*, is also weaker than the rest; and the wood gradually increases in strength as we recede from the centre to the blea.

3. The wood is stronger in the middle of the trunk than at the springing of the branches or at the root; and the wood of the branches is weaker than that of the trunk.

4. The wood of the north side of all trees which grow in our European climates is the weakest, and that of the south-east side is the strongest; and the difference is most remarkable in hedge row trees, and such as grow singly. The heart of a tree is never in its centre, but always nearer to the north side, and the annual coats of wood are thinner on that side. In conformity with this, it is a general opinion of carpenters that timber is stronger whose annual plates are thicker. The trachea or air-vessels are weaker than the simple ligneous fibres. These air-vessels are the same in diameter and number of rows in trees of the same species, and they make the visible separation between the annual plates. Therefore when these are thicker, they contain a greater proportion of the simple ligneous fibres.

5. All woods are more tenacious while green, and lose very considerably by drying after the trees are felled.

The only author who has put it in our power to judge of the propriety of his experiments is Muschenbroek. He has described his method of trial minutely, and it seems unexceptionable. The woods were all formed into slips fit for his apparatus, and part of the slip was cut away to a parallelopiped of $\frac{1}{4}$ th of an inch square, and therefore $\frac{1}{16}$ th of a square inch in section. The absolute strengths of a square inch were as follow:

lib.	lib.
Locust tree 20,100	Pomegranate 9,750
Jujeb - 18,500	Lemon 9,250
Beech, oak 17,300	Tamarind 8,750
Orange 15,500	Fir - 8,330
Alder - 13,900	Walnut 8,130
Elm - 13,200	Pitch pine 7,650
Mulberry 12,500	Quince - 6,750
Willow - 12,500	Cypress 6,000
Ash - 12,000	Poplar - 5,500
Plum - 11,800	Cedar - 4,880
Elder - 10,000	

Mr Muschenbroek has given a very minute detail of the experiments on the ash and the walnut, stating the weights which were required to tear asunder slips taken from the four sides of the tree, and on each side in a regular progression from the centre to the circumference. The numbers of this table corresponding to these two timbers may therefore be considered as the average of more than 50 trials made of each; and he says that all the others were made with the same care. We cannot therefore see any reason for not confiding in the results; yet they are considerably higher than those given by some other writers. Mr Pitot says, on the authority of his own experiments, and of those of Mr Parent, that 60 pounds will just tear asunder a square line of sound oak, and that it will bear 50 with safety. This gives 8640 for the utmost strength of a square inch, which is much inferior to Muschenbroek's valuation.

We may add to these,

lib.	lib.
Ivory - 16,270	
Bone - 5,250	
Horn - 8,750	
Whalebone - 7,500	
Tooth of sea-calf - 4,075	

The reader will surely observe, that these numbers express something more than the utmost cohesion; for the weights are such as will very quickly, that is, in a minute or two, tear the rods asunder. It may be said in general, that two-thirds of these weights will sensibly impair the strength after a considerable while, and that one half is the utmost that can remain suspended at them without risk for ever; and it is this last allotment that the engineer should reckon upon in his constructions. There is, however, considerable difference in this respect. Woods of a very straight fibre, such as fir, will be less impaired by any load which is not sufficient to break them immediately.

According to Mr Emerson, the load which may be safely suspended to an inch square is as follows:

Iron	76,400
Brass	35,600
Hemp rope	19,600
Ivory	15,700
Oak, box, yew, plum-tree	7,850
Elm, ash, beech	6,070
Walnut, plum	5,360
Red fir, holly, elder, plane, crab	5,000
Cherry, hazle	4,760
Alder, asp, birch, willow	4,290
Lead	430
Freestone	914

He gives us a practical rule, that a cylinder whose diameter is d inches, loaded to one-fourth of its absolute strength, will carry as follows:

Iron	135	Cwt.
Good rope	22	
Oak	14	
Fir	9	

The rank which the different woods hold in this list of Mr Emerson's is very different from what we find in Muschenbroek's. But precise measures must not be expected in this matter. It is wonderful that in a matter of such unquestionable importance the public has not enabled some persons of judgment to make proper trials. They are beyond the abilities of private persons.

II. BODIES MAY BE CRUSHED.

It is of equal, perhaps greater, importance to know the strain which may be laid on solid bodies without danger of crushing them. Pillars and posts of all kinds are exposed to this strain in its simplest form; and there are cases where the strain is enormous, viz. where it arises from the oblique position of the parts; as in the stuts, braces, and trusses, which occur very frequently in our great works.

It is therefore most desirable to have some general knowledge of the principle which determines the strength of bodies in opposition to this kind of strain. But unfortunately we are much more at a loss in this than in the last case. The mechanism of nature is much more complicated in the present case. It must be in some circuitous way that compression can have any tendency to tear asunder the parts of a solid body, and it is very difficult to trace the steps.

If we suppose the particles insuperably hard and in contact, and disposed in lines which are in the direction of the external pressures, it does not appear how any pressure can disunite the particles; but this is a gratuitous supposition. There are infinite odds against this precise arrangement of the lines of particles; and the compressibility of all kinds of matter in some degree shows that the particles are in a situation equivalent to distance. This being the case, and the particles, with their intervals, or what is equivalent to intervals,

Strength of
Materials.

Intervals, being in situations that are oblique with respect to the pressures, it must follow, that by squeezing them together in one direction, they are made to bulge out or separate in other directions. This may proceed so far that some may be thus pushed laterally beyond their limits of cohesion. The moment that this happens the resistance to compression is diminished, and the body will now be crushed together. We may form some notion of this by supposing a number of spherules, like small shot, sticking together by means of a cement. Compressing this in some particular direction causes the spherules to act among each other like so many wedges, each tending to penetrate through between the three which lie below it: and this is the simplest, and perhaps the only distinct, notion we can have of the matter. We have reason to think that the constitution of very homogeneous bodies, such as glass, is not very different from this. The particles are certainly arranged symmetrically in the angles of some regular solids. It is only such an arrangement that is consistent with transparency, and with the free passage of light in every direction.

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Their
strength
or power
of resist-
ance to
such a
force

If this be the constitution of bodies, it appears probable that the strength, or the resistance which they are capable of making to an attempt to crush them to pieces, is proportional to the area of the section whose plane is perpendicular to the external force; for each particle being similarly and equally acted on and resisted, the whole resistance must be as their number; that is, as the extent of the section.

Accordingly this principle is assumed by the few writers who have considered this subject; but we confess that it appears to us very doubtful. Suppose a number of brittle or friable balls lying on a table uniformly arranged, but not cohering nor in contact, and that a board is laid over them and loaded with a weight; we have no hesitation in saying, that the weight necessary to crush the whole collection is proportional to their number or to the area of the section. But when they are in contact (and still more if they cohere), we imagine that the case is materially altered. Any individual ball is crushed only in consequence of its being bulged outwards in the direction perpendicular to the pressure employed. If this could be prevented by a hoop put round the ball like an equator, we cannot see how any force can crush it. Any thing therefore which makes this bulging outwards more difficult, makes a greater force necessary. Now this effect will be produced by the mere contact of the balls before the pressure is applied; for the central ball cannot swell outward laterally without pushing away the balls on all sides of it. This is prevented by the friction on the table and upper board, which is, at least equal to one third of the pressure. Thus any interior ball becomes stronger by the mere vicinity of the others; and if we farther suppose them to cohere laterally, we think that its strength will be still more increased.

The analogy between these balls and the cohering particles of a friable body is very perfect. We should therefore expect that the strength by which it resists being crushed will increase in a greater ratio than that of the section, or the square of the diameter of similar sections; and that a square inch of any matter will bear a greater weight in proportion as it makes a part of a greater section. Accordingly this appears in many experiments, as will be noticed afterwards. Muschenbroek, Euler, and some others, have supposed the strength of columns to be as the biquadrates of their diameters. But Euler deduced this from formulæ which occurred to him in the course of his algebraic analysis; and he boldly adopts it as a principle, without looking for its foundation in the physical assumptions which he had made in the beginning of his investigation. But

some of his original assumptions were as paradoxical, or at least as gratuitous, as these results: and those, in particular, from which this proportion of the strength of columns was deduced, were almost foreign to the case; and therefore the inference was of no value. Yet it was received as a principle by Muschenbroek and by the academicians of St Petersburg. We make these very few observations, because the subject is of great practical importance; and it is a great obstacle to improvements when deference to a great name, joined to incapacity or indolence, causes authors to adopt his careless reveries as principles from which they are afterwards to draw important consequences. It must be acknowledged that we have not as yet established the relation between the dimensions and the strength of a pillar on solid mechanical principles. Experience plainly contradicts the general opinion, that the strength is proportional to the area of the section; but it is still more inconsistent with the opinion, that it is in the quadruplicate ratio of the diameters of similar sections. It would seem that the ratio depends much on the internal structure of the body; and experiment seems the only method for ascertaining its general laws.

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To be as-
certained
only by ex-
periment.

If we suppose the body to be of a fibrous texture, having the fibres situated in the direction of the pressure, and slightly adhering to each other by some kind of cement, such a body will fail only by the bending of the fibres, by which they will break the cement and be detached from each other. Something like this may be supposed in wooden pillars. In such cases, too, it would appear that the resistance must be as the number of equally resisting fibres, and as their mutual support, jointly; and, therefore, as some function of the area of the section. The same thing must happen if the fibres are naturally crooked or undulated, as is observed in many woods, &c. provided we suppose some similarity in their form. Similarity of some kind must always be supposed, otherwise we need never aim at any general inferences.

In all cases therefore we can hardly refuse admitting that the strength in opposition to compression is proportional to a function of the area of the section.

As the whole length of a cylinder or prism is equally pressed, it does not appear that the strength of a pillar is at all affected by its length. If indeed it be supposed to bend under the pressure, the case is greatly changed, because it is then exposed to a transverse strain; and this increases with the length of the pillar. But this will be considered with due attention under the next class of strains.

Few experiments have been made on this species of strength and strain. Mr Petit says, that his experiments, and those of Mr Parent, show that the force necessary for crushing a body is nearly equal to that which will tear it asunder. He says that it requires something more than 60 pounds on every square line to crush a piece of sound oak. But the rule is by no means general: Glass, for instance, will carry a hundred times as much as oak in this way, that is, resting on it; but will not *suspend* above four or five times as much. Oak will suspend a great deal more than fir; but fir will carry twice as much as a pillar. Woods of a soft texture, although consisting of very tenacious fibres, are more easily crushed by their load. This softness of texture is chiefly owing to their fibres not being straight but undulated, and there being considerable vacuities between them, so that they are easily bent laterally and crushed. When a post is overstrained by its load, it is observed to swell sensibly in diameter. Increasing the load causes longitudinal cracks or shivers to appear, and it presently after gives way. This is called *crippling*.

In all cases where the fibres lie oblique to the strain the strength is greatly diminished, because the parts can then be made

Strength of Materials. made to slide on each other, when the cohesion of the cementing matter is overcome.

Muschenbroek has given some experiments on this subject; but they are cases of long pillars, and therefore do not belong to this place. They will be considered afterwards.

The only experiments of which we have seen any detail (and it is useless to insert mere assertions) are those of Mr Gauthey, in the 4th volume of Rozier's *Journal de Physique*. This engineer exposed to great pressures small rectangular parallelepipeds, cut from a great variety of stones, and noted the weights which crushed them. The following table exhibits the medium results of many trials on two very uniform kinds of freestone, one of them among the hardest and the other among the softest used in building.

47
Experiments for this purpose made on freestone

Column 1st expresses the length AB of the section in French lines or 12ths of an inch; column 2d expresses the breadth BC; column 3d is the area of the section in square lines; column 4th is the number of ounces required to crush the piece; column 5th is the weight which was then borne by each square line of the section; and column 6th is the round numbers to which Mr Gauthey imagines that those in column 5th approximate.

Hard Stone.						
	AB	BC	AB × BC	Weight	Force	
1	8	8	64	736	11,5	12
2	8	12	96	2625	27,3	24
3	8	16	128	4496	35,1	36
Soft Stone.						
4	9	16	144	560	3,9	4
5	9	18	162	848	5,3	4,5
6	18	18	324	2928	9	9
7	18	24	432	5296	12,2	12

Little can be deduced from these experiments: The 1st and 3d, compared with the 5th and 6th, should furnish similar results; for the 1st and 5th are respectively half of the 3d and 6th: but the 3d is three times stronger (that is, a line of the 3d) than the first, whereas the 6th is only twice as strong as the 5th.

It is evident, however, that the strength increases much faster than the area of the section, and that a square line can carry more and more weight, according as it makes a part of a larger and larger section. In the series of experiments on the soft stone, the individual strength of a square line seems to increase nearly in the proportion of the section of which it makes a part.

Mr Gauthey deduces, from the whole of his numerous experiments, that a pillar of hard stone of Givry, whose section is a square foot, will bear with perfect safety 664,000 pounds, and that its extreme strength is 871,000, and the smallest strength observed in any of his experiments was 460,000. The soft bed of Givry stone had for its smallest strength 187,000, for its greatest 311,000, and for its safe load 249,000. Good brick will carry with safety 320,000; chalk will carry only 9000. The boldest piece of architecture in this respect which he has seen is a pillar in the church of All-Saints at Angers. It is 24 feet long and 11 inches square, and is loaded with 60,000, which is not $\frac{1}{4}$ th of what is necessary for crushing it.

50
Not satisfactory.

We may observe here by the way, that Mr Gauthey's measure of the suspending strength of stone is vastly small in proportion to its power of supporting a load laid above it. He finds that a prism of the hard bed of Givry, of a foot section, is torn asunder by 4600 pounds; and if it be firmly fixed horizontally in a wall, it will be broken by a weight of 56,000 suspended a foot from the wall. If it rest on two props at a foot distance, it will be broken by 206,000 laid on its middle. These experiments agree so ill with each

other, that little use can be made of them. The subject is of great importance, and well deserves the attention of the patriotic philosopher.

A set of good experiments would be very valuable, because it is against this kind of strain that we must guard by judicious construction in the most delicate and difficult problems which come through the hands of the civil and military engineer. The construction of stone arches, and the construction of great wooden bridges, and particularly the construction of the frames of carpentry called *centres* in the erection of stone bridges, are the most difficult jobs that occur. In the centres on which the arches of the bridge of Orleans were built some of the pieces of oak were carrying upwards of two tons on every square inch of their scantling. All who saw it said that it was not able to carry the fourth part of the intended load. But the engineer understood the principles of his art, and ran the risk: and the result completely justified his confidence; for the centre did not complain in any part, only it was found too supple; so that it went out of shape while the haunches only of the arch were laid on it. The engineer corrected this by loading it at the crown, and thus kept it completely in shape during the progress of the work.

In the Memoirs (old) of the Academy of Petersburg for 1778, there is a dissertation by Euler on this subject, but particularly limited to the strain on columns, in which the bending is taken into the account. Mr Fuls has treated the same subject with relation to carpentry in a subsequent volume. But there is little in these papers besides a dry mathematical disquisition, proceeding on assumptions which (to speak favourably) are extremely gratuitous. The most important consequence of the compression is wholly overlooked, as we shall presently see. Our knowledge of the mechanism of cohesion is as yet far too imperfect to entitle us to a confident application of mathematics. Experiments should be multiplied.

The only way we can hope to make these experiments useful is to pay a careful attention to the manner in which the fracture is produced. By discovering the general resemblances in this particular, we advance a step in our power of introducing mathematical measurement. Thus, when a cubical piece of chalk is slowly crushed between the chaps of a vice, we see it uniformly split in a surface oblique to the pressure, and the two parts then slide along the surface of fracture. This should lead us to examine mathematically what relation there is between this surface of fracture and the necessary force; then we should endeavour to determine experimentally the position of this surface. Having discovered some general law or resemblance in this circumstance, we should try what mathematical hypothesis will agree with this. Having found one, we may then apply our simplest notions of cohesion, and compare the result of our computations with experiment. We are authorised to say, that a series of experiments have been made in this way, and that their results have been very uniform, and therefore satisfactory, and that they will soon be laid before the public as the foundations of successful practice in the construction of arches.

III. A BODY MAY BE BROKEN ACROSS.

The most usual, and the greatest strain, to which materials are exposed, is that which tends to break them transversely. It is seldom, however, that this is done in a manner perfectly simple; for when a beam projects horizontally from a wall, and a weight is suspended from its extremity, the beam is commonly broken near the wall, and the intermediate part has performed the functions of a lever. It sometimes, though rarely, happens that the pin in the joint of a pair of pincers or scissars is cut through by the strain;

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How they are to be made useful.

53
It is of importance to know what strains a body will bear transversely.

Strength of
Materials.

54
Experi-
ments
made to
ascertain
it.

strain; and this is almost the only case of a simple transverse fracture. Being so rare, we may content ourselves with saying, that in this case the strength of the piece is proportional to the area of the section.

Experiments were made for discovering the resistances made by bodies to this kind of strain in the following manner: Two iron bars were disposed horizontally at an inch distance; a third hung perpendicularly between them, being supported by a pin made of the substance to be examined. This pin was made of a prismatic form, so as to fit exactly the holes in the three bars, which were made very exact, and of the same size and shape. A scale was suspended at the lower end of the perpendicular bar, and loaded till it tore out that part of the pin which filled the middle hole. This weight was evidently the measure of the lateral cohesion of two sections. The side-bars were made to grasp the middle bar pretty strongly between them, that there might be no distance imposed between the opposite pressures. This would have combined the energy of a lever with the purely transverse pressure. For the same reason it was necessary that the internal parts of the holes should be no smaller than the edges. Great irregularities occurred in our first experiments from this cause, because the pins were somewhat tighter within than at the edges; but when this was corrected they were extremely regular. We employed three sets of holes, viz. a circle, a square (which was occasionally made a rectangle whose length was twice its breadth), and an equilateral triangle. We found in all our experiments the strength exactly proportional to the area of the section, and quite independent of its figure or position, and we found it considerably above the direct cohesion; that is, it took considerably more than twice the force to tear out this middle piece than to tear the pin asunder by a direct pull. A piece of fine freestone required 205 pounds to pull it directly asunder, and 575 to break it in this way. The difference was very constant in any one substance, but varied from $\frac{4}{5}ds$ to $\frac{2}{3}ds$ in different kinds of matter, being smallest in bodies of a fibrous texture. But indeed we could not make the trial on any bodies of considerable cohesion, because they required such forces as our apparatus could not support. Chalk, clay baked in the sun, baked sugar, brick, and freestone, were the strongest that we could examine.

But the more common case, where the energy of a lever intervenes, demands a minute examination.

Let DABC (fig. 5. n° 1.) be a vertical section of a prismatic solid (that is, of equal size throughout), projecting horizontally from a wall in which it is firmly fixed; and let a weight P be hung on it at B, or let any power P act at B in a direction perpendicular to AB. Suppose the body of insuperable strength in every part except in the vertical section DA, perpendicular to its length. It must break in this section only. Let the cohesion be uniform over the whole of this section; that is, let each of the adjoining particles of the two parts cohere with an equal force f .

There are two ways in which it may break. The part ABCD may simply slide down along the surface of fracture, provided that the power acting at B is equal to the accumulated force which is exerted by every particle of the section in the direction AD.

But suppose this effectually prevented by something that supports the point A. The action at P tends to make the body turn round A (or round a horizontal line passing thro' A at right angles to AB) as round a joint. This it cannot do without separating at the line DA. In this case the adjoining particles at D or at E will be separated horizontally. But their cohesion resists this separation. In order, therefore, that the fracture may happen, the en-

ergy or momentum of the power P, acting by means of the lever AB, must be superior to the accumulated energies of the particles. The energy of each depends not only on its cohesive force, but also on its situation; for the supposed insuperable firmness of the rest of the body makes it a lever turning round the fulcrum A, and the cohesion of each particle, such as D or E, acts by means of the arm DA or EA. The energy of each particle will therefore be had by multiplying the force exerted by it in the instant of fracture by the arm of the lever by which it acts.

Let us therefore first suppose, that in the instant of fracture every particle is exerting an equal force f . The energy of D will be $f \times DA$, and that of E will be $f \times EA$, and that of the whole will be the sum of all these products. Let the depth DA of the section be called d , and let any undetermined part of it EA be called x , and then the space occupied by any particle will be x . The cohesion of this space may be represented by fx , and that of the whole by fd . The energy by which each element x of the line DA, or d , resists the fracture, will be $f \times x$, and the whole accumulated energies will be $f \times \frac{1}{2}d$, or $fd \times \frac{1}{2}$. It is the same therefore as if the cohesion fd of the whole section had been acting at the point G, which is in the middle of DA.

The reader who is not familiarly acquainted with this fluxionary calculus may arrive at the same conclusion in another way. Suppose the beam, instead of projecting horizontally from a wall, to be hanging from the ceiling, in which it is firmly fixed. Let us consider how the equal cohesion of every part operates in hindering the lower part from separating from the upper by opening round the joint A. The equal cohesion operates just as equal gravity would do, but in the opposite direction. Now we know, by the most elementary mechanics, that the effect of this will be the same as if the whole weight were concentrated in the centre of gravity G of the line DA, and that this point G is in the middle of DA. Now the number of fibres being as the length d of the line, and the cohesion of each fibre being $=f$, the cohesion of the whole line is $f \times d$ or fd .

The accumulated energy therefore of the cohesion in the instant of fracture is $fd \times \frac{1}{2}$. Now this must be equal or just inferior to the energy of the power employed to break it. Let the length AB be called l ; then $P \times l$ is the corresponding energy of the power. This gives us $fd \times \frac{1}{2} = pl$ for the equation of equilibrium corresponding to the vertical section ADCB.

Suppose now that the fracture is not permitted at DA, but at another section d' more remote from B. The body being prismatic, all the vertical sections are equal; and therefore $fd \times \frac{1}{2}$ is the same as before. But the energy of the power is by this means increased, being now $= P \times B d'$, instead of $P \times BA$: Hence we see that when the prismatic body is not insuperably strong in all its parts, but equally strong throughout, it must break close at the wall, where the strain or energy of the power is greatest. We see, too, that a power which is just able to break it at the wall is unable to break it anywhere else; also an absolute cohesion fd , which can withstand the power p in the section DA, will not withstand it in the section d' , and will withstand more in the section d'' .

This teaches us to distinguish between absolute and relative strength. The relative strength of a section has a reference to the strain actually exerted on that section. This relative strength is properly measured by the power which is just able to balance or overcome it, when applied at its proper

55
Their re-
sult.

56
The
strength
of a lever

Strength of Materials. $p = \frac{f d \frac{1}{2} d}{l}$ for the measure of the strength of the section

DA, in relation to the power applied at B.

If the solid is a rectangular beam, whose breadth is b , it is plain that all the vertical sections are equal, and that AC or $\frac{1}{2}d$ is the same in all. Therefore the equation expressing the equilibrium between the momentum of the external force and the accumulated momenta of cohesion will be $p l = f d b \times \frac{1}{2} d$.

The product $d b$ evidently expresses the area of the section of fracture, which we may call s , and we may express the equilibrium thus, $p l = f s \frac{1}{2} d$, and $2 l : d = f s : p$.

Now $f s$ is a proper expression of the absolute cohesion of the section of fracture, and p is a proper measure of its strength in relation to a power applied at B. We may therefore say, that *twice the length of a rectangular beam is to the depth as the absolute cohesion to the relative strength*.

Since the action of equable cohesion is similar to the action of equal gravity, it follows, that whatever is the figure of the section, the relative strength will be the same as if the absolute cohesion of all the fibres were acting at the centre of gravity of the section. Let g be the distance between the centre of gravity of the section and the axis of fracture, we shall have $p l = f s g$, and $l : g = f s : p$. It will be very useful to recollect this analogy in words: "*The length of a prismatic beam of any shape is to the height of the centre of gravity above the lower side, as the absolute cohesion to the strength relative to this length.*"

Because the relative strength of a rectangular beam is $\frac{f b d \frac{1}{2} d}{l}$ or $\frac{f b d^2}{2 l}$, it follows, that the relative strengths of different beams are proportional to the absolute cohesion of the particles, to the breadth, and to the square of the depth directly, and to the length inversely; also in prisms whose sections are similar, the strengths are as the cubes of the diameters.

57 Such are the more general results of the mechanism of this transverse strain, in the hypothesis that all the particles are exerting equal forces in the instant of fracture. We are indebted for this doctrine to the celebrated Galileo; and it was one of the first specimens of the application of mathematics to the science of nature.

We have not included in the preceding investigation that action of the external force by which the solid is drawn sidewise, or tends to slide along the surface of fracture. We have supposed a particle E to be pulled only in the direction $E e$, perpendicular to the section of fracture, by the action of the crooked lever BAE. But it is also pulled in the direction EA; and its reaction is in some direction e , compounded of f , by which it resists being pulled outwards; and e , by which it resists being pulled downwards. We are but imperfectly acquainted with the force e , and only know that their accumulated sum is equal to the force p : but in all important cases which occur in practice, it is unnecessary to attend to this force; because it is so small in comparison of the forces in the direction $E e$, as we easily conclude from the usual smallness of AD in comparison of AB.

58 The hypothesis of equal cohesion, exerted by all the particles in the instant of fracture, is not conformable to nature: for we know, that when a force is applied transversely at B, the beam is bent downwards, becoming convex on the upper side; that side is therefore on the stretch. The particles at D are farther removed from each other than those at E, and are therefore *actually exerting* greater cohesive forces. We cannot say with certainty and precision in what

proportion each fibre is extended. It seems most probable that the extensions are proportional to the distances from A. We shall suppose this to be really the case. Now recollect the general law which we formerly said was *observed* in all moderate extensions, *viz.* that the attractive forces exerted by the dilated particles were proportional to their dilations. Suppose now that the beam is so much bent that the particles at D are exerting their utmost force, and that this fibre is just ready to break or actually breaks. It is plain that a total fracture must immediately ensue; because the force which was superior to the full cohesion of the particle at D, and a certain portion of the cohesion of all the rest, will be more than superior to the full cohesion of the particle next within D, and a smaller portion of the cohesion of the remainder.

Now let F represent, as before, the full force of the exterior fibre D, which is exerted by it in the instant of its breaking, and then the force exerted at the same instant by the fibre E will be had by this analogy AD:AE, or $d : x = f : \frac{f x}{d}$, and the force really exerted by the fibre E is $f \times \frac{x}{d}$.

The force exerted by a fibre whose thickness is x is therefore $\frac{f x^2}{d}$; but this force resists the strain by acting by means of the lever EA or x . Its energy or momentum is therefore $\frac{f x^3}{d}$, and the accumulated momenta of all the fibres in the line AE will be $f \times$ sum of $\frac{x^3}{d}$.

This, when x is taken equal to d , will express the momentum of the whole fibres in the line AD. This, therefore, is $f \frac{1}{2} d^3$, or $f \frac{1}{2} d^2$, or $f d \times \frac{1}{2} d$. Now $f d$ expresses the absolute cohesion of the whole line AD. The accumulated momentum is therefore the same as if the absolute cohesion of the whole line were exerted at $\frac{1}{2} d$ of AD from A.

59 From these premises it follows that the equation expressing the equilibrium of the strain and cohesion is $p l = f d \times \frac{1}{2} d$; and hence we deduce the analogy, "*As thrice the length is to the depth, so is the absolute cohesion to the relative strength.*"

This equation and this proportion will equally apply to rectangular beams whose breadth is b ; for we shall then have $p l = f b d \times \frac{1}{2} d$.

We also see that the relative strength is proportional to the absolute cohesion of the particles, to the breadth, and to the square of the depth directly, and to the length inversely: for p is the measure of the force with which it is resisted, and $p = \frac{f b d \frac{1}{2} d}{l} = \frac{f b d^2}{3 l}$. In this respect therefore this hypothesis agrees with the Galilean; but it assigns to every beam a smaller proportion of the absolute cohesion of the section of fracture, in the proportion of 3 to 2. In the Galilean hypothesis this section has a momentum equal to $\frac{1}{2}$ of its absolute strength, but in the other hypothesis it is only $\frac{1}{3} d$. In beams of a different form the proportion may be different.

As this is a most important proposition, and the foundation of many practical maxims, we are anxious to have it clearly comprehended, and its evidence perceived by all. Our better informed readers will therefore indulge us while we endeavour to present it in another point of view, where it will be better seen by those who are not familiarly acquainted with the fluxionary calculus.

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proposition
presented
in another
point of
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Fig. 5. n^o 2. A is a perspective view of a three-sided beam projecting horizontally from a wall, and loaded with a weight at B just sufficient to break it. DABC is a vertical plane through its highest point D, in the direction of its length. aDa is another vertical section perpendicular to AB. The piece being supposed of insuperable strength everywhere except in the section aDa , and the cohesion being also supposed insuperable along the line aAa , it can break nowhere but in this section, and by turning round aAa as round a hinge. Make Dd equal to AD, and let Dd represent the absolute cohesion of the fibre at D, which absolute cohesion we express by the symbol f . Let a plane ada be made to pass through aa and d , and let $d'd'a'$ be another cross section. It is plain that the prismatic solid contained between the two sections aDa and $d'd'a'$ will represent the full cohesion of the whole section of fracture; for we may conceive this prism as made up of lines such as Ff , equal and parallel to Dd , representing the absolute cohesion of each particle such as F. The pyramidal solid dDa , cut off by the plane ada , will represent the cohesions actually exerted by the different fibres in the instant of fracture. For take any point E in the surface of fracture, and draw Ee parallel to AB, meeting the plane ada in e , and let eAe be a vertical plane. It is evident that Dd is to Ee as AD to AE; and therefore (since the forces exerted by the different fibres are as their extension, and their extension as their distances from the axis of fracture) Ee will represent the force actually exerted by the fibre in E, while D is exerting its full force Dd . In like manner, the plane Fff expresses the cohesion exerted by all the fibres in the line FF, and so on through the whole surface. Therefore the pyramid dDa expresses the accumulated exertion of the whole surface of fracture.

Farther, suppose the beam to be held perpendicular to the horizon with the end B uppermost, and that the weight of the prism contained between the two sections aDa and $d'd'a'$ (now horizontal) is just able to overcome the full cohesion of the section of fracture. The weight of the pyramid dDa will also be just able to overcome the cohesions actually exerted by the different fibres in the instant of fracture, because the weight of each fibre, such as Ee , is just superior to the cohesion actually exerted at E.

Let o be the centre of gravity of the pyramidal solid, and draw oO perpendicular to the plane aDa . The whole weight of the solid dDa may be conceived as accumulated in the point o , and as acting on the point O, and it will have the same tendency to separate the two cohering surfaces as when each fibre is hanging by its respective point. For this reason the point O may be called the *centre of actual effort* of the unequal forces of cohesion. The momentum therefore, or energy by which the cohering surfaces are separated, will be properly measured by the weight of the solid dDa multiplied by OA ; and this product is equal to the product of the weight p multiplied by BA, or by l . Thus suppose that the cohesion along the line AD only is considered. The whole cohesion will be represented by a triangle ADd , Dd represents f , and AD is d , and AD is x . Therefore ADd is $\frac{1}{2}fd$. The centre of gravity o of the triangle ADd is in the intersection of a line drawn from A to the middle of Dd with a line drawn from d to the middle of AD; and therefore the line oO will make $AO = \frac{1}{3}$ of AD. Therefore the actual momentum of cohesion is $f \times \frac{1}{2}d \times \frac{2}{3}d = f \times d \times \frac{1}{3}d = fd \times \frac{1}{3}d$, or equal to the

absolute cohesion acting by means of the lever $\frac{d}{3}$. If the section of fracture is a rectangle, as in a common joist, whose breadth aa is $=b$, it is plain that all the vertical lines

will be equal to AD, and their cohesions will be represented by triangles like ADd ; and the whole actual cohesion will be represented by a wedge whose bases are vertical planes, and which is equal to half of the parallelopiped $AD \times Dd \times aa$, and will therefore be $= \frac{1}{2}fbd$; and the distance AO of its centre of gravity from the horizontal line aAa will be $\frac{1}{3}$ of AD. The momentum of cohesion of a joist will therefore be $\frac{1}{2}fbd \times \frac{2}{3}d$, or $fbd \times \frac{1}{3}d$, as we have determined in the other way.

The beam represented in the figure is a triangular prism. The pyramid dDa is $\frac{1}{4}$ of the prism $aaDda'a'$. If we make s represent the surface of the triangle aDa , the pyramid is $\frac{1}{4}$ of fs . The distance AO of its centre of gravity from the horizontal line aAa is $\frac{1}{3}$ of AD, or $\frac{1}{3}d$. Therefore the momentum of actual cohesion is $\frac{1}{4}fs \times \frac{1}{3}d = fs \times \frac{1}{12}d$; that is, it is the same as if the full cohesion of all the fibres were accumulated at a point I whose distance from A is $\frac{1}{6}$ th of AD or d ; or (that we may see its value in every point of view) it is $\frac{1}{6}$ th of the momentum of the full cohesion of all the fibres when accumulated at the point D, or acting at the distance $d = AD$.

This is a very convenient way of conceiving the momentum of actual cohesion, by comparing it with the momentum of absolute cohesion applied at the distance AD from the axis of fracture. The momentum of the absolute cohesion applied at D is to the momentum of actual cohesion in the instant of fracture as AD to AI. Therefore the length of AI, or its proportion to AD, is a sort of index of the strength of the beam. We shall call it the INDEX, and express it by the symbol i .

Its value is easily obtained. The product of the absolute cohesion by AI must be equal to that of the actual cohesion by AO. Therefore say, "as the prismatic solid $aaDda'a'$ is to the pyramidal solid $aaDd$, so is AO to AI." We are assisted in this determination by a very convenient circumstance. In this hypothesis of the actual cohesions being as the distances of the fibres from A, the point O is the centre of oscillation or percussion of the surface Daa turning round the axis aa : for the momentum of cohesion of the line FF is $FF \times Ff \times EA = FF \times EA^2$, because Ff is equal to EA. Now AO, by the nature of the centre of gravity, is equal to the sum of all these momenta divided by the pyramid $aaDd$; that is, by the sum of all the $FF \times Ff$; that is, by the sum of all the $FF \times EA$.

Therefore $AO = \frac{\text{sum of } FF \times EA^2}{\text{sum of } FF \times EA}$, which is just the value of the distance of the centre of percussion of the triangle aDa from A: (See ROTATION). Moreover, if G be the centre of gravity of the triangle aDa , we shall have DA to GA as the absolute cohesion to the sum of the cohesions actually exerted in the instant of fracture; for, by the nature of this centre of gravity, AG is equal to

$\frac{\text{sum of } FF \times EA}{\text{sum of } FF}$, and the sum of $FF \times AG$ is equal to the sum of $FF \times EA$. But the sum of all the lines FF is the triangle aDa , and the sum of all the $FF \times EA$ is the sum of all the rectangles FFf ; that is, the pyramid dDa . Therefore a prism whose base is the triangle aDa , and whose height is AG, is equal to the pyramid, or will express the sum of the actual cohesions; and a prism, whose base is the same triangle, and whose height is Dd or Da , expresses the absolute cohesion. Therefore DA is to GA as the absolute cohesion to the sum of the actual cohesions.

Therefore we have $DA : GA = OA : IA$.

Therefore, whatever be the form of the beam, that is, whatever be the figure of its section, find the centre of oscillation O, and the centre of gravity G of this section.

Strength of Materials. Call their distances from the axis of fracture o and g . Then $\underbrace{AI \text{ or } i = \frac{og}{d}}$, and the momentum of cohesion is $fs \times \frac{og}{d}$, where s is the area of fracture.

This index is easily determined in all the cases which generally occur in practice. In a rectangular beam AI is $\frac{1}{2}d$ of AD ; in a cylinder (circular or elliptic) AI is $\frac{1}{8}$ ths of AD , &c. &c.

In this hypothesis, that the cohesion actually exerted by each fibre is as its extension, and that the extensions of the fibres are as their distances from A (fig. 5. n^o 1.), it is plain that the forces exerted by the fibres D , E , &c. will be represented by the ordinates Dd , Ee , &c. to a straight line Ad . And we learn from the principles of ROTATION that the centre of percussion O is in the ordinate which passes through the centre of gravity of the triangle Ad , or (if we consider the whole section having breadth as well as depth) through the centre of gravity of the solid bounded by the planes DA , dA ; and we found that this point O was the centre of effort of the cohesions actually exerted in the instant of fracture, and that I was the centre of an equal momentum, which would be produced if all the fibres were accumulated there and exerted their full cohesion.

This consideration enables us to determine, with equal facility and neatness, the strength of a beam in any hypothesis of forces. The above hypothesis was introduced with a cautious limitation to moderate strains, which produced no permanent change of form, or no sett as the artists call it: and this suffices for all purposes of practice, seeing that it would be imprudent to expose materials to more violent strains. But when we compare this theory with experiments in which the pieces are really broken, considerable deviations may be expected, because it is very probable that in the vicinity of rupture the forces are no longer proportional to the extensions.

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How the relative strength may be determined by any other hypothesis.

That no doubt may remain as to the justness and completeness of the theory, we must show how the relative strength may be determined in any other hypothesis. Therefore suppose that it has been established by experiment on any kind of solid matter, that the forces actually exerted in the instant of fracture by the fibres at D , E , &c. are as the ordinates Dd , Ee , &c. of any curve line Ad . We are supposed to know the form of this curve, and that of the solid which is bounded by the vertical plane through AD , and by the surface which passes through this curve Ad perpendicularly to the length of the beam. We know the place of the centre of gravity of this curve surface or solid, and can draw a line through it parallel to AB , and cutting the surface of fracture in some point O . This point is also the centre of effort of all the cohesions actually exerted; and the product of AO and of the solid which expresses the actual cohesions will give the momentum of cohesion equivalent to the former $fs \frac{og}{d}$. Or we may find an index

AI , by making AI a fourth proportional to the full cohesion of the surface of fracture, to the accumulated actual cohesions, and to AO ; and then $fs \times i (= AI)$ will be the momentum of cohesion; and we shall still have I for the point in which all the fibres may be supposed to exert their full cohesion f , and to produce a momentum of cohesion equal to the real momentum of the cohesions actually exerted, and the relative strength of the beam will still be $p = \frac{fsi}{l}$ or

$\frac{fsgo}{dl}$. Thus, if the forces be as the squares of the extensions (still supposed to be as the distances from A), the

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Strength of Materials. curve Ad will be a common parabola, having AB for its axis and AD for the tangent at its vertex. The area Ad will be $\frac{1}{2}d \times AD$; and in the case of a rectangular beam, AO will be $\frac{1}{4}$ ths AD , and AI will be $\frac{1}{4}$ th of AD .

We may observe here in general, that if the forces actually exerted in the instant of fracture be as any power q of the distance from A , the index AI will be $= \frac{AD}{q+2}$ for a rectangular beam, and the momentum of cohesion will always be (*ceteris paribus*) as the breadth and as the square of the depth; nay, this will be the case whenever the action of the fibres D and E is expressed by any similar functions of d and x . This is evident to every reader acquainted with the fluxionary calculus.

As far as we can judge from experience, no simple algebraic power of the distance will express the actual cohesions of the fibres. No curve which has either AD or AB for its tangent will suit. The observations which we made in the beginning show, that although the curve of fig. 2. must be sensibly straight in the vicinity of the points of intersection with the axis, in order to agree with our observations which show the moderate extensions to be as the extending forces, the curve must be concave towards the axis in all its attractive branches, because it cuts it again. Therefore the curve Ad of fig. 5. (n^o 1.) must make a finite angle with AD or AB , and it must, in all probability, be also concave towards AD in the neighbourhood of d . It may however be convex in some part of the intermediate arch. We have made experiments on the extensions of different bodies, and find great diversities in this respect: But in all, the moderate extensions were as the forces, and this with great accuracy till the body took a sett, and remained longer than formerly when the extending force was removed.

We must now remark, that this correction of the Galilean hypothesis of equal forces was suggested by the bending which is observed in all bodies which are strained transversely. Because they are bent, the fibres on the convex side have been extended. We cannot say in what proportion this obtains in the different fibres. Our most distinct notions of the internal equilibrium between the particles render it highly probable that their extension is proportional to their distance from that fibre which retains its former dimensions. But by whatever law this is regulated, we see plainly that the actions of the stretched fibres must follow the proportions of some function of this distance, and that therefore the relative strength of a beam is in all cases susceptible of mathematical determination.

We also see an intimate connection between the strain and the curvature. This suggested to the celebrated James Bernoulli the problem of the ELASTIC CURVE, i. e. the curve into which an extensible rigid body will be bent by a transverse strain. His solution in the *Acta Lipsie* 1694 and 1695 is a very beautiful specimen of mathematical discussion; and we recommend it to the perusal of the curious reader. He will find it very perspicuously treated in the first volume of his works, published after his death, where the wide steps which he had taken in his investigation are explained so as to be easily comprehended. His nephew Dan. Bernoulli has given an elegant abridgment in the *Petersburg Memoirs* for 1729. The problem is too intricate to be fully discussed in a work like ours; but it is also too intimately connected with our present subject to be entirely omitted. We must content ourselves with showing the leading mechanical property of this curve, from which the mathematician may deduce all its geometrical properties.

When a bar of uniform depth and breadth, and of a given length, is bent into an arch of a circle, the extension of the outer

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Bernoulli's problem of the elastic curve.

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Its leading
mechanical
property
described.

outer fibres is proportional to the curvature; for, because the curves formed by the inner and outer sides of the beam are similar, the circumferences are as the radii, and the radius of the inner circle is to the difference of the radii as the length of the inner circumference is to the difference of the circumferences. The difference of the radii is the depth of the beam, the difference of the circumferences is the extension of the outer fibres, and the inner circumference is supposed to be the primitive length of the beam. Now the second and third quantities of the above analogy, viz. the depth and length of the beam, are constant quantities, as is also their product. Therefore the product of the inner radius and the extension of the outer fibre is also a constant quantity, and the whole extension of the outer fibre is inversely as the radius of curvature, or is directly as the curvature of the beam.

The mathematical reader will readily see, that into whatever curve the elastic bar is bent, the whole extension of the outer fibre is equal to the length of a similar curve, having the same proportion to the thickness of the beam that the length of the beam has to the radius of curvature.

Now let ADCB (fig. 5. n° 3.) be such a rod, of uniform breadth and thickness, firmly fixed in a vertical position, and bent into a curve AEFB by a weight W suspended at B, and of such magnitude that the extremity B has its tangent perpendicular to the action of the weight, or parallel to the horizon. Suppose too that the extensions are proportional to the extending forces. From any two points E and F draw the horizontal ordinates EG, FH. It is evident that the exterior fibres of the sections Ee and Ff are stretched by forces which are in the proportion of EG to FH (these being the long arms of the levers, and the equal thicknesses Ee, Ff being the short arms). Therefore (by the hypothesis) their extensions are in the same proportion. But because the extensions are proportional to some similar functions of the distance from the axes of fracture E and F, the extension of any fibre in the section Ee is to the contemporaneous extension of the similarly situated fibre in the section Ff, as the extension of the exterior fibre in the section Ee is to the extension of the exterior fibre in the section Ff: therefore the whole extension of Ee is to the whole extension of Ff as EG to FH, and EG is to FH as the curvature in E to the curvature in F.

Here let it be remarked, that this proportionality of the curvature to the extension of the fibres is not limited to the hypothesis of the proportionality of the extensions to the extending forces. It follows from the extension in the different sections being as some similar function of the distance from the axis of fracture; an assumption which cannot be refused.

This then is the fundamental property of the elastic curve, from which its equation, or relation between the abscissa and ordinate, may be deduced in the usual forms, and all its other geometrical properties. These are foreign to our purpose; and we shall notice only such properties as have an immediate relation to the strain and strength of the different parts of a flexible body, and which in particular serve to explain some difficulties in the valuable experiments of Mr Buffon on the Strength of Beams.

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It is not a
circle.

We observe, in the first place, that the elastic curve cannot be a circle, but is gradually more incurvated as it recedes from the point of application B of the straining forces. At B it has no curvature; and if the bar were extended beyond B there would be no curvature there. In like manner, when a beam is supported at the ends and loaded in the middle, the curvature is greatest in the middle; but at the props, or beyond them, if the beam extend farther, there is no curvature. Therefore when a beam projecting 20 feet from

a wall is bent to a certain curvature at the wall by a weight suspended at the end, and a beam of the same size projecting 20 feet is bent to the very same curvature at the wall by a greater weight at 10 feet distance, the figure and the mechanical state of the beam in the vicinity of the wall is different in these two cases, though the curvature at the very wall is the same in both. In the first case every part of the beam is incurvated; in the second, all beyond the 10 feet is without curvature. In the first experiment the curvature at the distance of five feet from the wall is $\frac{1}{4}$ ths of the curvature at the wall; in the second, the curvature at the same place is but $\frac{1}{2}$ of that at the wall. This must weaken the long beam in this whole interval of five feet, because the greater curvature is the result of a greater extension of the fibres.

In the next place, we may remark, that there is a certain determinate curvature for every beam which cannot be exceeded without breaking it; for there is a certain separation of two adjoining particles that puts an end to their cohesion. A fibre can therefore be extended only a certain proportion of its length. The ultimate extension of the outer fibres must bear a certain determinate proportion to its length, and this proportion is the same with that of the thickness (or what we have hitherto called the depth) to the radius of ultimate curvature, which is therefore determinate.

A beam of uniform breadth and depth is therefore most incurvated where the strain is greatest, and will break in the most incurvated part. But by changing its form, so as to make the strength of its different sections in the ratio of the strain, it is evident that the curvature may be the same throughout, or may be made to vary according to any law. This is a remark worthy of the attention of the watchmaker. The most delicate problem in practical mechanics is so to taper the balance-spring of a watch that its wide and narrow vibrations may be isochronous. Hooke's principle *ut tensio sic vis* is not sufficient when we take the inertia and motion of the spring itself into the account. The figure into which it bends and unbends has also an influence. Our readers will take notice that the artist aims at an accuracy which will not admit an error of $\frac{1}{80150}$ th, and that Harrison and Arnold have actually attained it in several instances. The taper of a spring is at present a nostrum in the hands of each artist, and he is careful not to impart his secret.

Again, since the depth of the beam is thus proportional to the radius of ultimate curvature, this ultimate or breaking curvature is inversely as the depth. It may be expressed

by $\frac{1}{d}$.

When a weight is hung on the end of a prismatic beam, the curvature is nearly as the weight and the length directly, and as the breadth and the cube of the depth inversely; for the strength is $\propto \frac{bd^3}{l}$. Let us suppose that

this produces the ultimate curvature $\frac{1}{d}$. Now let the beam be loaded with a smaller weight w , and let the curvature produced be C, we have this analogy $\frac{bd^3}{3l} : w = \frac{1}{d} : C$, and $C = \frac{3lw}{bd^3}$. It is evident that this is also true of a beam

supported at the ends and loaded between the props; and we see how to determine the curvature in its different parts, whether arising from the load, or from its own weight, or from both.

When a beam is thus loaded at the end or middle, the loaded

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Every beam
has a cer-
tain deter-
minate cur-
vature.

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And when
of uniform
breadth and
depth is
most incur-
vated
where the
strain is
greatest.

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To what
the curva-
ture is pro-
portional.

Strength of Materials. 68 **Deflection.** loaded point is pulled down, and the space through which it is drawn may be called the DEFLECTION. This may be considered as the sub-tense of the angle of contact, or as the versed sine of the arch into which the beam is bent, and is therefore as the curvature when the length of the arches is given (the flexure being moderate), and as the square of the length of the arch when the curvature is given. The deflection therefore is as the curvature and as the square of

the length of the arch jointly; that is, as $\frac{3lw}{fb d^3} \times l^2$, or as

$\frac{3lw}{fb d^3}$. The deflection from the primitive shape is there-

fore as the bending weight and the cube of the length directly, and as the breadth and cube of the depth inversely.

69 **The theorems resulting from this subject afford the finest methods of examining the laws of corpuscular action.** In beams just ready to break, the curvature is as the depth inversely, and the deflection is as the square of the length divided by the depth; for the ultimate curvature at the breaking part is the same whatever is the length; and in this case the deflection is as the square of the length.

We have been the more particular in our consideration of this subject, because the resulting theorems afford us the finest methods of examining the laws of corpuscular action, that is, for discovering the variation of the force of cohesion by a change of distance. It is true it is not the atomical law, or HYLARCHIC PRINCIPLE as it may justly be called, which is thus made accessible, but the specific law of the particles of the substance or kind of matter under examination. But even this is a very great point; and coincidences in this respect among the different kinds of matter are of great moment. We may thus learn the nature of the corpuscular action of different substances, and perhaps approach to a discovery of the *mechanism* of chemical affinities. For that chemical actions are insensible cases of local motion is undeniable, and local motion is the province of mechanical discussion; nay, we see that these hidden changes are produced by mechanical forces in many important cases, for we see them promoted or prevented by means purely mechanical. The conversion of bodies into elastic vapour by heat can at all times be prevented by a sufficient external pressure. A strong solution of Glauber's salt will congeal in an instant by agitation, giving out its latent heat; and it will remain fluid for ever, and return its latent heat in a close vessel which it completely fills. Even water will by such treatment freeze in an instant by agitation, or remain fluid for ever by confinement. We know that heat is produced or extricated by friction, that certain compounds of gold or silver with saline matters explode with irresistible violence by the smallest pressure or agitation. Such facts should rouse the mathematical philosopher, and excite him to follow out the conjectures of the illustrious Newton, encouraged by the ingenious attempts of Bosovich; and the proper beginning of this study is to attend to the laws of attraction and repulsion exerted by the particles of cohering bodies, discoverable by experiments made on their actual extensions and compressions. The experiments of simple extensions and compressions are quite insufficient, because the total stretching of a wire is so small a quantity, that the mistake of the 1000th part of an inch occasions an irregularity which deranges any progression so as to make it useless. But by the bending of bodies, a distension of $\frac{1}{1000}$ th of an inch may be easily magnified in the deflection of the spring ten thousand times. We know that the investigation is intricate and difficult, but not beyond the reach of our present mathematical attainments; and it will give very fine opportunities of employing all the address of analysis. In the last century and the beginning of the present this was a sufficient excitement to the first ge-

niuses of Europe. The cycloid, the catenaria, the elastic curve, the velaria, the caustics, were reckoned an abundant recompense for much study; and James Bernoulli requested, as an honourable monument, that the logarithmic spiral might be inscribed on his tombstone. The reward for the study to which we now presume to incite the mathematicians is the almost unlimited extension of natural science, important in every particular branch. To go no further than our present subject, a great deal of important practical knowledge respecting the strength of bodies is derived from the single observation, that in the moderate extensions which happen before the parts are overstrained the forces are nearly in the proportion of the extensions or separations of the particles. To return to our subject.

James Bernoulli in his second dissertation on the elastic curve, calls in question this law, and accommodates his investigation to any hypothesis concerning the relation of the forces and extensions. He relates some experiments of lute strings where the relation was considerably different. Strings of three feet long,

Stretched by 2, 4, 6, 8, 10 pds.
Were lengthened 9, 17, 23, 27, 30 lines.

But this is a most exceptionable form of the experiment. The strings were twisted, and the mechanism of the extensions is here exceedingly complicated, combined with compressions and with transverse twists, &c. We made experiments on fine slips of the gum caoutchouc, and on the juice of the berries of the white bryony, of which a single grain will draw to a thread of two feet long, and again return into a perfectly round sphere. We measured the diameter of the thread by a microscope with a micrometer, and thus could tell in every state of extension the proportional number of particles in the sections. We found, that though the whole range in which the distance of the particles was changed in the proportion of 13 to 1, the extensions did not *sensibly* deviate from the proportion of the forces. The same thing was observed in the caoutchouc as long as it perfectly recovered its first dimensions. And it is on the authority of these experiments that we presume to announce this as a law of nature.

Dr Robert Hooke was undoubtedly the first who attended to this subject, and assumed this as a law of nature. Mariotté indeed was the first who expressly used it for determining the strength of beams: this he did about the 1679, correcting the simple theory of Galileo. Leibnitz indeed, in his dissertation in the *Acta Eruditorum* 1684 de *Resistentia Solidorum*, introduces this consideration, and wishes to be considered as the discoverer; and he is always acknowledged as such by the Bernoullis and others who adhered to his peculiar doctrines. But Mariotté had published the doctrine in the most express terms long before; and Bulfinger, in the *Comment. Petropol.* 1729, completely vindicates his claim. But Hooke was unquestionably the discoverer of this law. It made the foundation of his theory of springs, announced to the Royal Society about the year 1661, and read in 1666. On this occasion he mentions many things on the strength of bodies as quite familiar to his thoughts, which are immediate deductions from this principle; and among these *all* the facts which John Bernoulli so vauntingly adduces in support of Leibnitz's finical dogmas about the force of bodies in motion; a doctrine which Hooke might have claimed as his own, had he not perceived its frivolous inanity.

But even with this first correction of Mariotté, the mechanism of transverse strain is not fully nor justly explained. The force acting in the direction BP (fig. 5. n° 1.), and bending the body ABCD, not only stretches the fibres on the side opposite to the axis of fracture, but compresses the side AB, which becomes concave by the strain. Indeed it cannot do the one without doing the other: For in order to strain,

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70 Bernoulli calls in question this law.

71 Which was first assumed by Dr Hooke.

72 Though corrected by Mariotté it does not properly explain the mechanism of transverse strain.

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to stretch the fibres at D, there must be some fulcrum, some support, on which the virtual lever BAD may press, that it may tear asunder the stretched fibres. This fulcrum must sustain both the pressure arising from the cohesion of the distended fibres, and also the action of the external force, which immediately tends to cause the prominent part of the beam to slide along the section DA. Let BAD (fig. 5. n° 1.) be considered as a crooked lever, of which A is the fulcrum. Let an external force be applied at B in the direction BP, and let a force equal to the accumulated cohesion of AD be applied at O in the direction opposite to AB, that is, perpendicular to AO; and let these two forces be supposed to balance each other by the intervention of the lever. In the first place, the force at O must be to the force at B as AB to AO: Therefore, if we make AK equal and opposite to AO, and AL equal and opposite to AB, the common principles of mechanics inform us that the fulcrum A is affected in the same manner as if the two forces AK and AL were immediately applied to it, the force AK being equal to the weight P, and AL equal to the accumulated cohesion actually exerted in the instant of fracture. The fulcrum is therefore really pressed in the direction AM, the diagonal of the parallelogram, and it must resist in the direction and with the force MA; and this power of resistance, this support, must be furnished by the repulsive forces exerted by *those particles only* which are in a state of actual compression. The force AK, which is equal to the external force P, must be resisted in the direction KA by the lateral cohesion of the whole particles between D and A (the particle D is not only drawn forward but downward). This prevents the part CDAB from sliding down along the section DA.

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As is fully
verified by
experiment.

This is fully verified by experiment. If we attempt to break a long slip of cork, or any such very compressible body, we always observe it to bulge out on the concave side before it cracks on the other side. If it is a body of fibrous or foliated texture, it seldom fails splintering off on the concave side; and in many cases this splintering is very deep, even reaching half way through the piece. In hard and granulated bodies, such as a piece of freestone, chalk, dry clay, sugar, and the like, we generally see a considerable splinter or shiver fly off from the hollow side. If the fracture be slowly made by a force at B gradually augmented, the formation of the splinter is very distinctly seen. It forms a triangular piece like *a I b*, which generally breaks in the middle. We doubt not but that attentive observation would show that the direction of the crack on each side of I is not very different from the direction AM and its correspondent on the other side. This is by no means a circumstance of idle curiosity, but intimately connected with the mechanism of cohesion.

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Consequences
resulting from
the state
of the case.

Let us see what consequences result from this state of the case respecting the strength of bodies. Let $D \Delta KC$ (fig. 6.) represent a vertical section of a prism of compressible materials, such as a piece of timber. Suppose it loaded with a weight P hung at its extremity. Suppose it of such a constitution that all the fibres in AD are in a state of dilatation, while those in $A \Delta$ are in a state of compression. In the instant of fracture the particles at D and E are withheld by forces D *d*, E *e*, and the particles at Δ and E repel, resist, or support, with forces $\Delta \delta$, E *e*.

Some line, such as *d e A \delta*, will limit all these ordinates, which represent the forces actually exerted in the instant of fracture. If the forces are as the extensions and compressions, as we have great reason to believe, *d e A* and $A \delta$ will be two straight lines. They will form one straight line *d A \delta*, if the forces which resist a certain dilatation are equal to the forces which resist an equal compression. But this is

quite accidental, and is not strictly true in any body. In most bodies which have any considerable firmness, the compressions made by any external force are not so great as the dilatations which the same force would produce; that is, the repulsions which are excited by any supposed degree of compression are greater than the attractions excited by the same degree of dilatation. Hence it will generally follow, that the angle *d A D* is less than the angle $\delta A \Delta$, and the ordinates D *d*, E *e*, &c. are less than the corresponding ordinates $\Delta \delta$, E *e*, &c.

But whatever be the nature of the line *d A \delta*, we are certain of this, that the whole area AD *d* is equal to the whole area $A \Delta \delta$: for as the force at B is gradually increased, and the parts between A and D are more extended, and greater cohesive forces are excited, there is always such a degree of repulsive forces excited in the particles between A and Δ that the one set precisely balances the other. The force at B, acting perpendicularly to AB, has no tendency to push the whole piece closer on the part next the wall or to pull it away. The sum of the attractive and repulsive forces actually excited must therefore be equal. These sums are represented by the two triangular areas, which are therefore equal.

The greater we suppose the repulsive forces corresponding to any degree of compression, in comparison with the attractive forces corresponding to the same degree of extension, the smaller will $A \Delta$ be in comparison of AD. In a piece of cork or sponge, $A \Delta$ may chance to be equal to AD, or even to exceed it; but in a piece of marble, $A \Delta$ will perhaps be very small in comparison of AD.

Now it is evident that the repulsive forces excited between A and Δ have no share in preventing the fracture. They rather contribute to it, by furnishing a fulcrum to the lever, by whose energy the cohesion of the particles in AD is overcome. Hence we see an important consequence of the compressibility of the body. Its power of resisting this transverse strain is diminished by it, and so much the more diminished as the stuff is more compressible.

This is fully verified by some very curious experiments made by Du Hamel. He took 16 bars of willow 2 feet long and $\frac{1}{2}$ an inch square, and supporting them by props under the ends, he broke them by weights hung on the middle. He broke 4 of them by weights of 40, 41, 47, and 52 pounds: the mean is 45. He then cut 4 of them $\frac{1}{2}$ d through on the upper side, and filled up the cut with a thin piece of harder wood stuck in pretty tight. These were broken by 48, 54, 50, and 52 pounds; the mean of which is 51. He cut other four $\frac{1}{2}$ through, and they were broken by 47, 49, 50, 46; the mean of which is 48. The remaining four were cut $\frac{3}{4}$ ds; and their mean strength was 42.

Another set of his experiments is still more remarkable.

Six battens of willow 36 inches long and $1\frac{1}{4}$ square were broken by 525 pounds at a medium.

Six bars were cut $\frac{1}{2}$ d through, and the cut filled with a wedge of hard wood stuck in with a little force: these broke with 551.

Six bars were cut half through, and the cut was filled in the same manner: they broke with 542.

Six bars were cut $\frac{3}{4}$ ths through: these broke with 530.

A batten cut $\frac{3}{4}$ ths through, and loaded till nearly broken, was unloaded, and the wedge taken out of the cut. A thicker wedge was put in tight, so as to make the batten straight again by filling up the space left by the compression of the wood: this batten broke with 577 pounds.

From this it is plain that more than $\frac{3}{4}$ ds of the thickness (perhaps nearly $\frac{3}{4}$ ths) contributed nothing to the strength.

The point A is the centre of fracture in this case; and in order to estimate the strength of the piece, we may suppose

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An important
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pose that the crooked lever virtually concerned in the strain is DAB. We must find the point I, which is the centre of effort of all the attractive forces, or that point where the full cohesion of AD must be applied, so as to have a momentum equal to the accumulated momenta of all the variable forces. We must in like manner find the centre of effort i of the repulsive or supporting forces exerted by the fibres lying between A and Δ .

It is plain, and the remark is important, that this last centre of effort is the real fulcrum of the lever, although A is the point where there is neither extension nor contraction; for the lever is supported in the same manner as if the repulsions of the whole line A Δ were exerted at that point. Therefore let S represent the surface of fracture from A to D, and f represent the absolute cohesion of a fibre at D in the instant of fracture. We shall have $fS \times I + i = p l$, or $I : I + i = fS : p$; that is, the length AB is to the distance between the two centres of effort I and i , as the absolute cohesion of the section between A and D is to the relative strength of the section.

It would be perhaps more accurate to make AI and Ai equal to the distances of A from the horizontal lines passing through the centres of gravity of the triangles dAD and $dA\Delta$. It is only in this construction that the points I and i are the centres of real effort of the accumulated attractions and repulsions. But I and i , determined as we have done, are the points where the full, equal, actions may be all applied, so as to produce the same momenta. The final results are the same in both cases. The attentive and duly informed reader will see that Mr Bulfinger, in a very elaborate dissertation on the strength of beams in the *Comment. Petropolit.* 1729, has committed several mistakes in his estimation of the actions of the fibres. We mention this because his reasonings are quoted and appealed to as authorities by Muschenbroek and other authors of note. The subject has been considered by many authors on the continent. We recommend to the reader's perusal the very minute discussions in the Memoirs of the Academy of Paris for 1702 by Varignon, the Memoirs for 1708 by Parent, and particularly that of Coulomb in the *Mem. par les Sçavans Étrangers*, tom. vii.

It is evident, from what has been said above, that if S and s represent the surfaces of the sections above and below A, and if G and g are the distances of their centres of gravity from A, and O and o the distances of their centres of oscillation, and D and d their whole depths, the momentum of cohesion will be $\frac{fS \cdot G \cdot O}{D} + \frac{fs \cdot g \cdot o}{d} = p l$.

If (as is most likely) the forces are proportional to the extensions and compressions, the distances AI and Ai, which are respectively $\frac{G \cdot O}{D}$ and $\frac{g \cdot o}{d}$, are respectively $= \frac{1}{3} DA$, and $\frac{1}{3} \Delta A$; and when taken together are $= \frac{1}{3} D\Delta$. If, moreover, the extensions are equal to the compressions in the instant of fracture, and the body is a rectangular prism like a common joist or beam, then DA and ΔA are also equal; and therefore the momentum of cohesion is $fb \times \frac{1}{3} d \times \frac{1}{3} d = \frac{fb d^2}{6}$, $= fbd \times \frac{1}{6} d = p l$. Hence we obtain this analogy, "Six times the length is to the depth as the absolute cohesion of the section is to its relative strength."

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This consequence farther explained.

Thus we see that the compressibility of bodies has a very great influence on their power of withstanding a transverse strain. We see that in this most favourable supposition of equal dilatations and compressions, the strength is reduced to one half of the value of what it would have been had the body been incompressible. This is by no means

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obvious; for it does not readily appear how compressibility, which does not diminish the cohesion of a single fibre, should impair the strength of the whole. The reason, however, is sufficiently convincing when pointed out. In the instant of fracture a smaller portion of the section is actually exerting cohesive forces, while a part of it is only serving as a fulcrum to the lever, by whose means the strain on the section is produced. We see too that this diminution of strength does not so much depend on the sensible compressibility, as on its proportion to the dilatability by equal forces. When this proportion is small, A Δ is small in comparison of AD, and a greater portion of the whole fibre is exerting attractive forces. The experiments already mentioned of Du Hamel de Monceau on battens of willow show that its compressibility is nearly equal to its dilatability. But the case is not very different in tempered steel. The famous Harrison, in the delicate experiments which he made while occupied in making his longitude watch, discovered that a rod of tempered steel was nearly as much diminished in its length as it was augmented by the same external force. But it is not by any means certain that this is the proportion of dilatation and compression which obtains in the very instant of fracture. We rather imagine that it is not. The forces are nearly as the dilatations till very near breaking; but we think that they diminish when the body is just going to break. But it seems certain that the forces which resist compression increase faster than the compressions, even before fracture. We know incontestably that the ultimate resistances to compression are insuperable by any force which we can employ. The repulsive forces therefore (in their whole extent) increase faster than the compressions, and are expressed by an asymptotic branch of the Boscovician curve formerly explained. It is therefore probable, especially in the more simple substances, that they increase faster, even in such compressions as frequently obtain in the breaking of hard bodies. We are disposed to think that this is always the case in such bodies as do not fly off in splinters on the concave side; but this must be understood with the exception of the permanent changes which may be made by compression, when the bodies are crippled by it. This always increases the compression itself, and causes the neutral point to shift still more towards D. The effect of this is sometimes very great and fatal.

Experiment alone can help us to discover the proportion between the dilatability and compressibility of bodies. The strain now under consideration seems the best calculated for this research. Thus if we find that a piece of wood an inch square requires 12,000 pounds to tear it asunder by a direct pull, and that 200 pounds will break it transversely by acting 10 inches from the section of fracture, we must conclude that the neutral point A is in the middle of the depth, and that the attractive and repulsive forces are equal. Any notions that we can form of the constitution of such fibrous bodies as timber, make us imagine that the *sensible* compressions, including what arises from the bending up of the compressed fibres, is much greater than the real corpuscular extensions. One may get a general conviction of this unexpected proposition by reflecting on what must happen during the fracture. An undulated fibre can only be drawn straight, and then the corpuscular extension begins; but it may be bent up by compression to any degree, the corpuscular compression being little affected all the while. This observation is very important; and though the forces of corpuscular repulsion may be almost insuperable by any compression that we can employ, a *sensible* compression may be produced by forces not enormous, sufficient to cripple the beam. Of this we shall see very important instances afterwards.

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The pro-
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strengths of
different
pieces of
the same
ratio.

It deserves to be noticed, that although the relative strength of a prismatic solid is extremely different in the three hypotheses now considered, yet the proportional strengths of different pieces follow the same ratio; namely, the direct ratio of the breadth, the direct ratio of the square of the depth, and the inverse ratio of the length. In the first hypothesis (of equal forces) the strength of a rectangular beam was $\frac{f b d^2}{2 l}$; in the second (of attractive forces proportional to the extensions) it was $\frac{f b d^2}{3 l}$; and in the third (equal attractions and repulsions proportional to the extensions and compressions) it was $\frac{f b d^2}{6 l}$, or more generally $\frac{f b d^2}{m l}$, where m expresses the unknown proportion between the attractions and repulsions corresponding to an equal extension and compression.

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The
strength of
a piece de-
pends chief-
ly on its
depth.

Hence we derive a piece of useful information, which is confirmed by unexcepted experience, that the strength of a piece depends chiefly on its depth, that is, on that dimension which is in the direction of the strain. A bar of timber of one inch in breadth and two inches in depth is four times as strong as a bar of only one inch deep, and it is twice as strong as a bar two inches broad and one deep; that is, a joist or lever is always strongest when laid on its edge.

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And there-
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There is therefore a choice in the manner in which the cohesion is opposed to the strain. The general aim must be to put the centre of effort I as far from the fulcrum or the neutral point A as possible, so as to give the greatest energy or momentum to the cohesion. Thus if a triangular bar projecting from a wall is loaded with a weight at its extremity, it will bear thrice as much when one of the sides is uppermost as when it is undermost. The bar of fig. 5. n^o 2. would be three times as strong if the side AB were uppermost and the edge DC undermost.

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The strong-
est joist has
not the
greatest
quantity of
timber.

Hence it follows that the strongest joist that can be cut out of a round tree is not the one which has the greatest quantity of timber in it, but such that the product of its breadth by the square of its depth shall be the greatest possible. Let $ABCD$ (fig. 7.) be the section of this joist inscribed in the circle, AB being the breadth and AD the depth. Since it is a rectangular section, the diagonal BD is a diameter of the circle, and BAD is a right angled triangle. Let BD be called a , and BA be called x ; then AD is $= \sqrt{a^2 - x^2}$. Now we must have $AB \times AD^2$, or $x \times a^2 - x^3$, or $a^2 x - x^3$, a maximum. Its fluxion $a^2 x - 3x^2$ must be made $= 0$, or $a^2 = 3x^2$, or $x^2 = \frac{a^2}{3}$.

If therefore we make $DE = \frac{1}{3} DB$, and draw EC perpendicular to BD , it will cut the circumference in the point C , which determines the depth BC and the breadth CD .

Because $BD : BC = CD : CE$, we have the area of the section $BC \cdot CD = BD \cdot CE$. Therefore the different sections having the same diagonal BD are proportional to their heights CE . Therefore the section $BCDA$ is less than the section $BcD a$, whose four sides are equal. The joist so shaped, therefore, is both stronger, lighter, and cheaper.

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A hollow
tube strong-
er than a
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containing
the same
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The strength of $ABCD$ is to that of $a B c D$ as 10,000 to 9186, and the weight and expence as 10,000 to 10,607; so that $ABCD$ is preferable to $a B c D$ in the proportion of 10,607 to 9186, or nearly 115 to 100.

From the same principles it follows that a hollow tube is stronger than a solid rod containing the same quantity of matter. Let fig. 8. represent the section of a cylindric tube, of which AF and BE are the exterior and interior

diameters and C the centre. Draw BD perpendicular to BC , and join DC . Then, because $BD^2 = CD^2 - CB^2$, BD is the radius of a circle containing the same quantity of matter with the ring. If we estimate the strength by the first hypothesis, it is evident that the strength of the tube will be to that of the solid cylinder, whose radius is BD , as $BD^2 \times AC$ to $BD^2 \times BD$; that is, as AC to BD : for BD^2 expresses the cohesion of the ring or the circle, and AC and BD are equal to the distances of the centres of effort (the same with the centres of gravity) of the ring and circle from the axis of fracture.

The proportion of these strengths will be different in the other hypotheses, and is not easily expressed by a general formula; but in both it is still more in favour of the ring or hollow tube.

The following very simple solution will be readily understood by the intelligent reader. Let O be the centre of oscillation of the exterior circle, o the centre of oscillation of the inner circle, and w the centre of oscillation of the ring included between them. Let M be the quantity of surface of the exterior circle, m that of the inner circle, and μ that of the ring.

We have $F w = \frac{M \cdot FO - m \cdot Fo}{\mu} = \frac{5 FC^2 + EC^2}{4 FC}$, and

the strength of the ring $= \frac{f \mu \times F w}{2}$, and the strength of

the same quantity of matter in the form of a solid cylinder is $f \mu \times \frac{1}{8} BD$; so that the strength of the ring is to that of the solid rod of equal weight as $F w$ to $\frac{1}{8} BD$, or nearly as FC to BD . This will easily appear by recollecting that

FO is $= \frac{\text{sum of } p \cdot r^2}{m \cdot FC}$ (see ROTATION), and that the mo-

mentum of cohesion is $\frac{f m \cdot FC \cdot Fa}{2 FC} = \frac{f m \cdot Fo}{2}$ for the inner circle, &c.

Emerson has given a very inaccurate approximation to this value in his *Mechanics*, 4to.

This property of hollow tubes is accompanied also with greater stiffness; and the superiority in strength and stiffness is so much the greater as the surrounding shell is thinner in proportion to its diameter.

Here we see the admirable wisdom of the Author of the nature in forming the bones of animal limbs hollow. The wisdom of bones of the arms and legs have to perform the office of levers, and are thus opposed to very great transverse strains. By this form they become incomparably stronger and stiffer, and give more room for the insertion of muscles, while they are lighter and therefore more agile; and the same Wisdom has made use of this hollow for other valuable purposes of the animal economy. In like manner the quills in the wings of birds acquire by their thinness the very great strength which is necessary, while they are so light as to give sufficient buoyancy to the animal in the rare medium in which it must live and fly about. The stalks of many plants, such as all the grasses, and many reeds, are in like manner hollow, and thus possess an extraordinary strength. Our best engineers now begin to imitate nature by making many parts of their machines hollow, such as their axles of cast iron, &c.; and the ingenious Mr Ramsden now makes the axes and framings of his great astronomical instruments in the same manner.

In the supposition of homogeneous texture, it is plain that the fracture happens as soon as the particles at D are separated beyond their utmost limit of cohesion. This is a determined quantity, and the piece bends till this degree of extension is produced in the outermost fibre. It follows, that the smaller we suppose the distance between A and D , the

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And more
stiff.

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Hence the
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forming the
bones, &c.
hollow.

Strength of Materials. The greater will be the curvature which the beam will acquire before it breaks. Greater depth therefore makes a beam not only stronger but also stiffer. But if the parallel fibres can slide on each other, both the strength and the stiffness will be diminished. Therefore if, instead of one beam $D \triangle KC$, we suppose two, $DABC$ and $A \triangle KB$, not cohering, each of them will bend, and the extension of the fibres AB of the under beam will not hinder the compression of the adjoining fibres AB of the upper beam. The two together therefore will not be more than twice as strong as one of them (supposing $DA = A \triangle$) instead of being four times as strong; and they will bend as much as either of them alone would bend by half the load. This may be prevented, if it were possible to unite the two beams all along the seam AB , so that the one shall not slide on the other. This may be done in small works, by gluing them together with a cement as strong as the natural lateral cohesion of the fibres. If this cannot be done (as it cannot in large works), the sliding is prevented by JOGGING the beams together; that is, by cutting down several rectangular notches in the upper side of the lower beam, and making similar notches in the under side of the upper beam, and filling up the square spaces with pieces of very hard wood firmly driven in, as represented in fig. 9. Some employ iron bolts by way of joggles. But when the joggle is much harder than the wood into which it is driven, it is very apt to work loose, by widening the hole into which it is lodged. The same thing is sometimes done by scarfing the one upon the other, as represented in fig. 9. (no 2.); but this wastes more timber, and is not so strong, because the mutual hooks which this method forms on each beam are very apt to tear each other up. By one or other of these methods, or something similar, may a compound beam be formed, of any depth, which will be almost as stiff and strong as an entire piece.

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How a strong compound beam may be formed.

On the other hand, we may combine strength with pliability, by composing our beam of several thin planks laid on each other, till they make a proper depth, and leaving them at full liberty to slide on each other. It is in this manner that coach-springs are formed, as is represented in fig. 10. In this assemblage there must be no joggles nor bolts of any kind put through the planks or plates; for this would hinder their mutual sliding. They must be kept together by straps which surround them, or by something equivalent.

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How strength may be combined with pliability.

The preceding observations show the propriety of some maxims of construction, which the artists have derived from long experience.

Thus, if a mortise is to be cut out of a piece which is exposed to a cross strain, it should be cut out from that side which becomes concave by the strain, as in fig. 11. but by no means as in fig. 12.

If a piece is to be strengthened by the addition of another, the added piece must be joined to the side which grows convex by the strain, as in fig. 13. and 14.

Before we go any farther, it will be convenient to recall the reader's attention to the analogy between the strain on a beam projecting from a wall and loaded at the extremity, and a beam supported at both ends and loaded in some intermediate point. It is sufficient on this occasion to read attentively what is delivered in the article ROOF, no 19.—We learn there that the strain on the middle point C (fig. 14. of the present article) of a rectangular beam AB , supported on props at A and B , is the same as if the part CA projected from a wall, and were loaded with the half of the weight W suspended at A . The momentum of the strain is therefore $\frac{1}{2} W \times \frac{1}{2} AB$, $= W \times \frac{1}{4} AB = p \frac{1}{4} l$, or $\frac{pl}{4}$.

Strength of Materials. The momentum of cohesion must be equal to this in every hypothesis.

Having now considered in sufficient detail the circumstances which affect the strength of any section of a solid body that is strained transversely, it is necessary to take notice of some of the chief modifications of the strain itself. We shall consider only those that occur most frequently in our constructions.

The strain depends on the external force, and also on the lever by which it acts.

It is evidently of importance, that since the strain is exerted in any section by means of the cohesion of the parts intervening between the section under consideration and the point of application of the external force, the body must be able in all these intervening parts to propagate or excite the strain in the remote section. In every part it must be able to resist the strain excited in that part. It should therefore be equally strong; and it is useless to have any part stronger, because the piece will nevertheless break where it is not stronger throughout; and it is useless to make it stronger (relatively to its strain) in any part, for it will nevertheless equally fail in the part that is too weak.

Suppose then, in the first place, that the strain arises from a weight suspended at one extremity, while the other end is firmly fixed in a wall. Supposing also the cross sections to be all rectangular, there are several ways of shaping the beam so that it shall be equally strong throughout. Thus it may be equally deep in every part, the upper and under surfaces being horizontal planes. The condition will be fulfilled by making all the horizontal sections triangles, as in fig. 15. The two sides are vertical planes meeting in an edge at the extremity L . For the equation expressing the balance of strain and strength is $p l = f b d^2$. Therefore since d^2 is the same throughout, and also p , we must have $f b = l$, and b (the breadth AD of any section $ABCD$) must be proportional to l (or AL), which it evidently is.

Or, if the beam be of uniform breadth, we must have d^2 everywhere proportional to l . This will be obtained by making the depths the ordinates of a common parabola, of which L is the vertex and the length is the axis. The upper or under side may be a straight line, as in fig. 16. or the middle line may be straight, and then both upper and under surfaces will be curved. It is almost indifferent what is the shape of the upper and under surfaces, provided the distances between them in every part be as the ordinates of a common parabola.

Or, if the sections are all similar, such as circles, squares, or any other similar polygons, we must have d^3 or b^3 proportional to l , and the depths or breadths must be as the ordinates of a cubical parabola.

It is evident that these are also the proper forms for a lever moveable round a fulcrum, and acted on by a force at the extremity. The force comes in the place of the weight suspended in the cases already considered; and as such levers always are connected with another arm, we readily see that both arms should be fashioned in the same manner. Thus in fig. 15. the piece of timber may be supposed a kind of steelyard, moveable round a horizontal axis OP , in the front of the wall, and having the two weights P and π in equilibrium. The strain occasioned by each at the section in which the axis OP is placed must be the same, and each arm OL and $O\pi$ must be equally strong in all its parts. The longitudinal sections of each arm must be a triangle, a common parabola, or a cubic parabola, according to the conditions previously given.

And, moreover, all these forms are equally strong: For any one of them is equally strong in all its parts, and they are all supposed to have the same section at the front of the wall.

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Materials.

Strength of wall or at the fulcrum. They are not, however, equally stiff. The first, represented in fig. 15. will bend least upon the whole, and the one formed by the cubic parabola will bend most. But their curvature at the very fulcrum will be the same in all.

It is also plain, that if the lever is of the second or third kind, that is, having the fulcrum at one extremity, it must still be of the same shape; for in abstract mechanics it is indifferent which of the three points is considered as the axis of motion. In every lever the two forces at the extremities act in one direction, and the force in the middle acts in the opposite direction, and the great strain is always at that point. Therefore a lever such as fig. 15. moveable round an axis passing horizontally through λ , and acting against an obstacle at OP, is equally able in all its parts to resist the strains excited in those parts.

The same principles and the same construction will apply to beams, such as joists, supported at the ends L and λ (fig. 15.), and loaded at some intermediate part OP. This will appear evident by merely inverting the directions of the forces at these three points, or by recurring to the article Roofs, n° 19.

89

The external strain-
ing force
may be di-
stributed
over the
beam.

Hitherto we have supposed the external straining force as acting only in one point of the beam. But it may be uniformly distributed all over the beam. To make a beam in such circumstances equally strong in all its parts, the shape must be considerably different from the former.

Thus suppose the beam to project from a wall.

90

To make a
beam strong
which pro-
jects from
a wall.

If it be of equal breadth throughout, its sides being vertical planes parallel to each other and to the length, the vertical section in the direction of its length must be a triangle instead of a common parabola; for the weight uniformly distributed over the part lying beyond any section, is as the length beyond that section: and since it may all be conceived as collected at its centre of gravity, which is the middle of that length, the lever by which this load acts or strains the section is also proportional to the same length. The strain on the section (or momentum of the load) is as the square of that length. The section must have strength in the same proportion. Its strength being as the breadth and the square of the depth, and the breadth being constant, the square of the depth of any section must be as the square of its distance from the end, and the depth must be as that distance; and therefore the longitudinal vertical section must be a triangle.

But if all the transverse sections are circles, squares, or any other similar figures, the strength of every section, or the cube of the diameter, must be as the square of the lengths beyond that section, or the square of its distance from the end; and the sides of the beam must be a semicubical parabola.

If the upper and under surfaces are horizontal planes, it is evident that the breadth must be as the square of the distance from the end, and the horizontal sections may be formed by arches of the common parabola, having the length for their tangent at the vertex.

By recurring to the analogy so often quoted between a projecting beam and a joist, we may determine the proper form of joists which are uniformly loaded through their whole length.

91

The strain
upon a
beam sup-
ported at
both ends.

This is a frequent and important case, being the office of joists, rafters, &c. and there are some circumstances which must be particularly noticed, because they are not so obvious, and have been misunderstood. When a beam AB (fig. 17.) is supported at the ends, and a weight is laid on any point P, a strain is excited in every part of the beam. The load on P causes the beam to press on A and B, and the props react with forces equal and opposite to these

pressures. The load at P is to the pressures at A and B as AB to PB and PA, and the pressures at A is to that at B as PB to PA; the beam therefore is in the same state, with respect to strain in every part of it, as if it were resting on a prop at P, and were loaded at the ends with weights equal to the two pressures on the props: and observe, these pressures are such as will balance each other, being inversely as their distances from P. Let P represent the weight or load at P. The pressure on the prop P must

be $P \times \frac{PA}{AB}$. This is therefore the reaction of the prop B, and is the weight which we may suppose suspended at B, when we conceive the beam resting on a prop at P, and carrying the balancing weights at A and B.

The strain occasioned at any other point C, by the load P at P, is the same with the strain at C, by the weight $P \times \frac{PA}{AB}$ hanging at B, when the beam rests on P, in the manner now supposed; and it is the same if the beam, instead of being balanced on a prop at P, had its part AP fixed in a wall. This is evident. Now we have shown at

length that the strain at C, by the weight $P \times \frac{PA}{AB}$ hanging at B, is $P \times \frac{PA}{AB} \times BC$. We desire it to be particularly

remarked that the pressure at A has no influence on the strain at C, arising from the action of any load between A and C; for it is indifferent how the part AP of the projecting beam PB is supported. The weight at A just performs the same office with the wall in which we suppose the beam to be fixed. We are thus particular, because we have seen even persons not unaccustomed to discussions of this kind puzzled in their conceptions of this strain.

Now let the load P be laid on some point p between C and B. The same reasoning shows us that the point is (with respect to strain) in the same state as if the beam were fixed in a wall, embracing the part pB , and a weight $= P \times \frac{pB}{AB}$ were hung on at A, and the strain at C is $P \times \frac{pB}{AB} \times AC$.

In general, therefore, the strain on any point C, arising from a load P laid on another point P, is proportional to the rectangle of the distances of P and C from the ends nearest to each. It is $P \times \frac{PA \times CB}{AB}$, or $P \times \frac{pB \times CA}{AB}$, according as the load lies between C and A or between C and B.

Cor. 1. The strains which a load on any point P occasions on the points C, c , lying on the same side of P, are as the distances of these points from the end B. In like manner the strains on E and e are as EA and eA .

Cor. 2. The strain which a load occasions in the part on which it rests is as the rectangle of the parts on each side. Thus the strain occasioned at C by a load is to that at D by the same load as $AC \times CB$ to $AD \times DB$. It is therefore greatest in the middle.

Let us now consider the strain on any point C arising from a load uniformly distributed along the beam. Let AP be represented by x , and Pp by $\dot{x}$, and the whole weight on the beam by a . Then

The weight on Pp is $= a \frac{\dot{x}}{AB}$

Pressure on B by the weight on Pp $= a \frac{\dot{x}}{AB} \times \frac{x}{AB}$

Or

92
A general
proposi-
tion.

93
The strain
arising
from a load
distributed
along the
beam.

Strength of
Materials. Or

$$= a \frac{x^2}{AB^2}$$

$$\text{Pres. on B by the whole wt. on AC} = a \frac{\frac{1}{2}AC^2}{AB^2} = a \frac{AC^2}{2AB^2}$$

$$\text{Strain at C by the weight on AC} = a \frac{AC^2 \times BC}{2AB^2}$$

$$\text{Strain at C by the weight on BC} = a \frac{BC^2 \times AC}{2AB^2}$$

$$\text{Do. by the whole weight on AB} = a \frac{AC^2 \times BC + BC^2 \times AC}{2AB^2}$$

$$= a \frac{AC \times BC \times AC + CB}{2AB^2} = a \frac{AC \times BC}{2AB}$$

Thus we see that the strain is proportional to the rectangle of the parts, in the same manner as if the load a had been laid directly on the point C, and is indeed equal to one-half of the strain which would be produced at C by the load a laid on there.

94 Mistakes in this subject committed by authors of reputation. It was necessary to be thus particular, because we see in some elementary treatises of mechanics, published by authors of reputation, mistakes which are very plausible, and mislead the learner. It is there said, that the pressure at B from a weight uniformly diffused along AB is the same as if it were collected at its centre of gravity, which would be the middle of AB; and then the strain at C is said to be this pressure at B multiplied by BC. But surely it is not difficult to see the difference of these strains. It is plain that the pressure of gravity downwards on any point between the end A and the point C has no tendency to diminish the strain at C, arising from the upward reaction of the prop B; whereas the pressure of gravity between C and B is almost in direct opposition to it, and must diminish it. We may however avoid the fluxionary calculus with safety by the consideration of the centre of gravity, by supposing the weights of AC and BC to be collected at their respective centres of gravity; and the result of this computation will be the same as above: and we may use either method, although the weight is not uniformly distributed, provided only that we know in what manner it is distributed.

This investigation is evidently of importance in the practice of the engineer and architect, informing them what support is necessary in the different parts of their constructions. We considered some cases of this kind in the article

ROOFS.

95 To form a joist which may have the same relative strength in all its parts. It is now easy to form a joist, so that it shall have the same relative strength in all its parts.

I. To make it equally able in all its parts to carry a given weight laid on any point C taken at random, or uniformly diffused over the whole length, the strength of the section at the point C must be as $AC \times CB$. Therefore

1. If the sides are parallel vertical planes, the square of the depth (which is the only variable dimension) or CD^2 , must be as $AC \times CB$, and the depths must be ordinates of an ellipse.

2. If the transverse sections are similar, we must make CD^3 as $AC \times CB$.

3. If the upper and under surfaces are parallel, the breadth must be as $AC \times CB$.

II. If the beam is necessarily loaded at some given point C, and we would have the beam equally able in all its parts to resist the strain arising from the weight at C, we must make the strength of every transverse section between C and either end as its distance from that end. Therefore

1. If the sides are parallel vertical planes, we must make $CD^3 : EF^3 = AC : AE$.

2. If the sections are similar, then $CD^3 : EF^3 = AC : AE$.

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3. If the upper and under surfaces are parallel, then, Strength of Materials. breadth at C : breadth at E = AC : AE.

The same principles enable us to determine the strain and strength of square or circular plates, of different extent, but equal thickness. This may be comprehended in this general proposition.

Similar plates of equal thickness supported all round will carry the same absolute weight, uniformly distributed, or resting on similar points, whatever is their extent.

Suppose two similar oblong plates of equal thickness, and let their lengths and breadths be L, l, and B, b. Let their strength or momentum of cohesion be C, c, and the strains from the weights W, w, be S, s.

Suppose the plates supported at the ends only, and resisting fracture transversely. The strains, being as the weights and lengths, are as WL and w l, but their cohesion are as the breadths; and since they are of equal relative strength, we have WL : w l = B : b, and WLb = w l B and L : l = w B : W b: but since they are of similar shapes L : l = B : b, and therefore w = W.

The same reasoning holds again when they are also supported along the sides, and therefore holds when they are supported all round (in which case the strength is doubled).

And if the plates are of any other figure, such as circles or ellipses, we need only conceive similar rectangles inscribed in them. These are supported all round by the continuity of the plates, and therefore will sustain equal weights; and the same may be said of the segments which lie without them, because the strengths of any similar segments are equal, their lengths being as their breadths.

Therefore the thickness of the bottoms of vessels holding heavy liquors or grains should be as their diameters, and as the square root of their depths jointly.

Also the weight which a square plate will bear is to that which a bar of the same matter and thickness will bear as twice the length of the bar to its breadth.

97 There is yet another modification of the strain which tends to break a body transversely, which is of very frequent occurrence, and in some cases must be very carefully attended to, viz. the strain arising from its own weight. The strain of a beam arising from its own weight.

When a beam projects from a wall, every section is strained by the weight of all that projects beyond it. This may be considered as all collected at its centre of gravity. Therefore the strain on any section is in the joint ratio of the weight of what projects beyond it, and the distance of its centre of gravity from the section.

The determination of this strain and of the strength necessary for withstanding it must be more complicated than the former, because the form of the piece which results from this adjustment of strain and strength influences the strain. The general principle must evidently be, that the strength or momentum of cohesion of every section must be as the product of the weight beyond it multiplied by the distance of its centre of gravity. For example:

Suppose the beam DLA (fig. 18.) to project from the wall, and that its sides are parallel vertical planes, so that the depth is the only variable dimension. Let LB = x and B b = y. The element B b c C is = y x. Let G be the centre of gravity of the part lying without B b, and g be its distance from the extremity L. Then x - g is the arm of the lever by which the strain is excited in the section B b. Let B b or y be as some power m of L B; that is, let y = x^m. Then the contents of LB b is $\frac{x^{m+1}}{m+1}$. The momentum of gravity round a horizontal axis at L is $y \times x = x^{m+1}$, and the whole momentum round the axis is $\frac{x^{m+2}}{m+2}$. The distance of

Strength of the centre of gravity from L is had by dividing this momentum by the whole weight, which is $\frac{x^{m+1}}{m+1}$. The quo-

tient or g is $\frac{x \times m+1}{m+2}$. And the distance of the centre

of gravity from the section Bb is $x - \frac{x \times m+1}{m+2} = \frac{x \times m+2 - x \times m+1}{m+2} = \frac{x}{m+2}$. Therefore the strain on the

section Bb is had by multiplying $\frac{x^{m+1}}{m+1}$ by $\frac{x}{m+2}$. The product is $\frac{x^{m+2}}{m+2 \times m+1}$. This must be as the square of the

depth, or as y^2 . But y is as x^m , and y^2 as x^{2m} . Therefore we have $m+2 = 2m$, and $m=2$; that is, the depth must be as the square of the distance from the extremity, and the curve LbA is a parabola touching the horizontal line in L.

99
A conoid
equally
able in eve-
ry section
to bear its
own
weight.

It is easy to see that a conoid formed by the rotation of this figure round DL will also be equally able in every section to bear its own weight.

We need not prosecute this farther. When the figure of the piece is given, there is no difficulty in finding the strain; and the circumstance of equal strength to resist this strain is chiefly a matter of curiosity.

100
The more
a beam
projects, the
less able it
is to bear
its own
weight.

It is evident, from what has been already said, that a projecting beam becomes less able to bear its own weight, as it projects farther. Whatever may be the strength of the section DA, the length may be such that it will break by its own weight. If we suppose two beams A and B of the same substance and similar shapes, that is, having their lengths and diameters in the same proportion; and farther suppose that the shorter can just bear its own weight; then the longer beam will not be able to do the same: For the strengths of the sections are as the cubes of the diameters, while the strains are as the biquadrates of the diameters; because the weights are as the cubes, and the levers by which these weights act in producing the strain are as the lengths or as the diameters.

101
Small bo-
dies more
able to
withstand
the strain
produced
by the
weight of
the ma-
chine than
great bo-
dies.

These considerations show us, that in all cases where the strain is affected by the weight of the parts of the machine or structure of any kind, the smaller bodies are more able to withstand it than the greater; and there seems to be bounds set by nature to the size of machines constructed of any given materials. Even when the weight of the parts of the machine is not taken into the account, we cannot enlarge them in the same proportion in all their parts. Thus a steam-engine cannot be doubled in all its parts, so as to be still efficient. The pressure on the piston is quadrupled. If the lift of the pump be also doubled in height while it is doubled in diameter, the load will be increased eight times, and will therefore exceed the power. The depth of lift, therefore, must remain unchanged; and in this case the machine will be of the same relative strength as before, independent of its own weight. For the beam being doubled in all its dimensions, its momentum of cohesion is eight times greater, which is again a balance for a quadruple load acting by a double lever.—But if we now consider the increase of the weight of the machine itself, which must be supported, and which must be put in motion by the intervention of its cohesion, we see that the large machine is weaker and less efficient than the small one.

There is a similar limit set by nature to the size of plants and animals formed of the same matter. The cohesion of an herb could not support it if it were increased to the size of a tree, nor could an oak support itself if 40 or

50 times bigger, nor could an animal of the make of a long-legged spider be increased to the size of a man; the articulations of its legs could not support it.

Hence may be understood the prodigious superiority of the small animals both in strength and agility. A man by falling twice his own height may break his firmest bones. A mouse may fall 20 times its height without risk; and even the tender mite or wood-louse may fall unhurt from the top of a steeple. But their greatest superiority is in respect of nimbleness and agility. A flea can leap above 500 times its own length, while the strength of the human muscles could not raise the trunk from the ground on limbs of the same construction.

The angular motions of small animals (in which consists their nimbleness or agility) must be greater than those of large animals, supposing the force of the muscular fibre to be the same in both. For supposing them similar, the number of equal fibres will be as the square of their linear dimensions; and the levers by which they act are as their linear dimensions. The energy therefore of the moving force is as the cube of these dimensions. But the momentum of inertia, or $\int p \cdot r^2$, is as the 4th power: Therefore the angular velocity of the greater animals is smaller. The number of strokes which a fly makes with its wings in a second is astonishingly great; yet, being voluntary, they are the effects of its agility.

We have hitherto confined our attention to the simplest form in which this transverse strain can be produced. This was quite sufficient for showing us the mechanism of nature by which the strain is resisted; and a very slight attention is sufficient for enabling us to reduce to this every other way in which the strain can be produced. We shall not take up the reader's time with the application of the same principles to other cases of this strain, but refer him to what has been said in the article ROOFS. In that article we have shown the analogy between the strain on the section of a beam projecting from a wall and loaded at the extremity, and the strain on the same section of a beam simply resting on supports at the ends, and loaded at some intermediate point or points. The strain on the middle C of a beam AB (fig. 19.) so supported, arising from a weight laid on there, is the same with the strain which half that weight hanging at B would produce on the same section C if the other end of the beam were fixed in a wall. If therefore 1000 pounds hung on the end of a beam projecting 10 feet from a wall will just break it at the wall, it will require 4000 pounds on its middle to break the same beam resting on two props 10 feet asunder. We have also shown in that article the additional strength which will be given to this beam by extending both ends beyond the props, and there framing it firmly into other pillars or supports. We can hardly add any thing to what has been said in that article, except a few observations on the effects of the obliquity of the external force. We have hitherto supposed it to act in the direction BP (fig. 6.) perpendicular to the length of the beam. Suppose it to act in the direction BP', oblique to BA. In the article ROOF we supposed the strain to be the same as if the force p acted at the distance AB', but still perpendicular to AB: so it is. But the strength of the section AA is not the same in both cases; for by the obliquity of the action the piece DCKA is pressed to the other. We are not sufficiently acquainted with the corpuscular forces to say precisely what will be the effect of the pressure arising from this obliquity; but we can clearly see, in general, that the point A, which in the instant of fracture is neither stretched nor compressed, must now be farther up, or nearer to

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Effects of
the obliqui-
ty of the
external
force.

Strength of Materials. to D; and therefore the number of particles which are exerting cohesive forces is smaller, and therefore the strength is diminished. Therefore, when we endeavour to proportion the strength of a beam to the strain arising from an external force acting obliquely, we make too liberal allowance by increasing this external force in the ratio of AB to AB. We acknowledge our inability to assign the proper correction. But this circumstance is of very great influence. In many machines, and many framings of carpentry, this oblique action of the straining force is unavoidable; and the most enormous strains to which materials are exposed are generally of this kind. In the frames set up for carrying the ring-stones of arches, it is hardly possible to avoid them: for although the judicious engineer disposes his beams so as to sustain only pressures in the direction of their lengths, tending either to crush them or to tear them asunder, it frequently happens that, by the settling of the work, the pieces come to check and bear on each other transversely, tending to break each other across. This we have remarked upon in the article Roofs, with respect to a truss by Mr Price (see Roofs, n^o 40, 41, 45). Now when a cross strain is thus combined with an enormous pressure in the direction of the length of the beam, it is in the utmost danger of snapping suddenly across. This is one great cause of the carrying away of masts. They are compressed in the direction of their length by the united force of the shrouds, and in this state the transverse action of the wind soon completes the fracture.

104 The strain on columns. When considering the compressing strains to which materials are exposed, we deferred the discussion of the strain on columns, observing that it was not, in the cases which usually occur, a simple compression, but was combined with a transverse strain, arising from the bending of the column. When the column ACB (fig. 20.) resting on the ground at B, and loaded at top with a weight A, acting in the vertical direction AB, is bent into a curve ACB, so that the tangent at C is perpendicular to the horizon, its condition somewhat resembles that of a beam firmly fixed between B and C, and strongly pulled by the end A, so as to bend it between C and A. Although we cannot conceive how a force acting on a straight column AB in the direction AB can bend it, we may suppose that the force acted first in the horizontal direction A b, till it was bent to this degree, and that the rope was then gradually removed from the direction A b to the direction AB, increasing the force as much as is necessary for preserving the same quantity of flexure.

105 Observations on Euler's theory of the strength of columns. The first author (we believe) who considered this important subject with scrupulous attention was the celebrated Euler, who published in the Berlin Memoirs for 1757 his Theory of the Strength of Columns. The general proposition established by this theory is, that the strength of prismatical columns is in the direct quadruplicate ratio of their diameters and the inverse duplicate ratio of their lengths. He prosecuted this subject in the Petersburg Commentaries for 1778, confirming his former theory. We do not find that any other author has bestowed much attention on it, all seeming to acquiesce in the determinations of Euler, and to consider the subject as of very great difficulty, requiring the application of the most refined mathematics. Muschenbroek has compared the theory with experiment; but the comparison has been very unsatisfactory, the difference from the theory being so enormous as to afford no argument for its justness. But the experiments do not contradict it, for they are so anomalous as to afford no conclusion or general rule whatever.

To say the truth, the theory can be considered in no other light than as a specimen of ingenious and very artful algebraic analysis. Euler was unquestionably the first analyst

in Europe for resource and address. He knew this, and enjoyed his superiority, and without scruple admitted any physical assumptions which gave him an opportunity of displaying his skill. The inconsistency of his assumptions with the known laws of mechanism gave him no concern; and when his algebraic processes led him to any conclusion which would make his readers stare, being contrary to all our usual notions, he frankly owned the paradox, but went on in his analysis, saying, "*Sed analysi magis fidendum.*" Mr Robins has given some very risible instances of this confidence in his analysis, or rather of his confidence in the indolent submission of his readers. Nay, so fond was he of this kind of amusement, that after having published an untenable Theory of Light and Colours, he published several Memoirs, explaining the aberration of the heavenly bodies, and deducing some very wonderful consequences, fully confirmed by experience, from the Newtonian principles, which were opposite and totally inconsistent with his own theory, merely because the Newtonian theory gave him "*occasionem analyseos promovendæ.*" We are thus severe in our observations, because his theory of the strength of columns is one of the strongest instances of this wanton kind of proceeding, and because his followers in the Academy of St Petersburg, such as Mr Fufs, Lexill, and others, adopt his conclusions, and merely echo his words. Since the death of Dan. Bernoulli no member of that academy has controverted any thing advanced by their *Professor sublimis geometriæ*, to whom they had been indebted for their places and for all their knowledge, having been (most of them) his amanuenses, employed by this wonderful man during his blindness to make his computations and carry on his algebraic investigations. We are not a little surprised to see Mr Emerson, a considerable mathematician, and a man of very independent spirit, hastily adopting the same theory, of which we doubt not but our readers will easily see the falsity.

Euler considers the column ACB as in a condition precisely similar to that of an elastic rod bent into the curve by a cord AB connecting its extremities.—In this he is not mistaken.—But he then draws CD perpendicular to AB, and considers the strain on the section C as equal to the momentum or mechanical energy of the weight A acting in the direction DB upon the lever $\times c$ D, moveable round the fulcrum c , and tending to tear asunder the particles which cohere along the section c C $\times$. This is the same principle (as Euler admits) employed by James Bernoulli in his investigation of the elastic curve ACB. Euler considers the strain on the section c $\times$ as the same with what it would sustain if the same power acted in the horizontal direction EF on a point E as far removed from C as the point D is. We reasoned in the same manner (as has been observed) in the article Roofs, where the obliquity of action was inconsiderable. But in the present case, this substitution leads to the greatest mistakes, and has rendered the whole of this theory false and useless. It would be just if the column were of materials which are incompressible. But it is evident, by what has been said above, that by the compression of the parts the real fulcrum of the lever shifts away from the point c , so much the more as the compression is greater. In the great compressions of loaded columns, and the almost unmeasurable compressions of the truss beams in the centres of bridges, and other cases of chief importance, the fulcrum is shifted far over towards $\times$, so that very few fibres resist the fracture by their cohesion; and these few have a very feeble energy or momentum, on account of the short arm of the lever by which they act. This is a most important consideration in carpentry, yet makes no element of Euler's theory. The consequence of this is, that a very small degree of curvature is sufficient to cause the co-

Strength of
Materials.

lumn or strutt to snap in an instant, as is well known to every experienced carpenter. The experiment by Muschenbroek, which Euler makes use of in order to obtain a measure of strength in a particular instance, from which he might deduce all others by his theorem, is an incontestable proof of this. The force which broke the column is not the twentieth part of what is necessary for breaking it by acting at E in the direction EF. Euler takes no notice of this immense discrepancy, because it must have caused him to abandon the speculation with which he was then amusing himself.

106

This theory
is false and
useless.

The limits of this Work do not afford room to enter minutely upon the refutation of this theory; but we can easily show its uselessness, by its total inconsistency with common observation. It results legitimately from this theory, that if CD have no magnitude, the weight A can have no momentum, and the column cannot be broken—True,—it cannot be broken in this way, snapped by a transverse fracture, if it do not bend; but we know very well that it can be crushed or crippled, and we see this frequently happen. This circumstance or event does not enter into Euler's investigation, and therefore the theory is imperfect at least and useless. Had this crippling been introduced in the form of a physical assumption, every topic of reasoning employed in the process must have been laid aside, as the intelligent reader will easily see. But the theory is not only imperfect, but false. The ordinary reader will be convinced of this by another legitimate consequence of it. Fig. 20. n° 2. is the same with fig. 106 of *Emerson's Mechanics*, where this subject is treated on Euler's principles, and represents a crooked piece of matter resting on the ground at F, and loaded at A with a weight acting in the vertical direction AF. It results from Euler's theory that the strains at b, B, D, E, &c. are as bc , BC, DI, EK, &c. Therefore the strains at G and H are nothing; and this is asserted by Emerson and Euler as a serious truth; and the piece may be thinned *ad infinitum* in these two places, or even cut through, without any diminution of its strength. The absurdity of this assertion strikes at first hearing. Euler asserts the same thing with respect to a point of contrary flexure. Farther discussion is (we apprehend) needless.

107

Yet Euler's
dissertations
deserve a perusal.

This theory must therefore be given up. Yet these dissertations of Euler in the *Petersburgh Commentaries* deserve a perusal, both as very ingenious specimens of analysis, and because they contain maxims of practice which are important. Although they give an erroneous measure of the comparative strength of columns, they show the immense importance of preventing all bendings, and point out with accuracy where the tendencies to bend are greatest, and how this may be prevented by very small forces, and what a prodigious accession of force this gives the column. There is a valuable paper in the same volume by Fufs on the *Strains on framed Carpentry*, which may also be read with advantage.

It will now be asked, what shall be substituted in place of this erroneous theory? what is the true proportion of the strength of columns? We acknowledge our inability to give a satisfactory answer. Such can be obtained only by a previous knowledge of the proportion between the extensions and compressions produced by equal forces, by the knowledge of the absolute compressions producible by a given force, and by a knowledge of the degree of that derangement of parts which is termed crippling. These circumstances are but imperfectly known to us, and there lies before us a wide field of experimental inquiry. Fortunately the force requisite for crippling a beam is prodigious, and a very small lateral support is sufficient to prevent that bending which puts the beam in imminent danger. A judicious engineer will always employ transverse bridle, as they

are called, to stay the middle of long beams, which are employed as pillars, struts, or truss beams, and are exposed, by their position, to enormous pressures in the direction of their lengths. Such stays may be observed, disposed with great judgment and economy, in the centres employed by Mr Perronet in the erection of his great stone arches. He was obliged to correct this omission made by his ingenious predecessor in the beautiful centres of the bridge of Orleans, which we have no hesitation in affirming to be the finest piece of carpentry in the world.

It only remains on this head to compare these theoretical deductions with experiment.

Experiments on the transverse strength of bodies are easily made, and accordingly are very numerous, especially those made on timber, which is the case most common and most interesting. But in this great number of experiments there are very few from which we can draw much practical information. The experiments have in general been made on such small scantlings, that the unavoidable natural inequalities bear too great a proportion to the strength of the whole piece. Accordingly, when we compare the experiments of different authors, we find them differ enormously, and even the experiments by the same author are very anomalous. The completest series that we have yet seen is that detailed by Belidor in his *Science des Ingenieurs*. They are contained in the following table. The pieces were sound, even-grained oak. The column *b* contains the breadths of the pieces in inches; the column *d* contains their depths; the column *l* contains their lengths; column *p* contains the weights (in pounds) which broke them when hung on their middles; and *m* is the column of averages or mediums.

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Table of
experiments
made by
Belidor.

N°	<i>b</i>	<i>d</i>	<i>l</i>	<i>p</i>	<i>m</i>
1	1	1	18	400 415 405	406
2	1	1	18	600 600 624	608
3	2	1	18	810 795 812	805
4	1	2	18	1570 1580 1590	1580
5	1	1	36	185 195 180	187
6	1	1	36	285 280 285	283
7	2	2	36	1550 1620 1585	1585
8	1½	2½	36	1665 1675 1640	1660

The ends lying loose.

The ends firmly fixed.

Loose.

Loose.

Loose.

Fixed.

Loose.

Loose.

By

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A new theory
cannot be substituted
in place of Euler's,
till many experiments
be made.

Strength of Materials. By comparing Experiments 1st and 3d, the strength appears proportional to the breadth.

Experiments 3d and 4th shew the strength proportional to the square of the depth.

Experiments 1st and 5th shew the strength nearly in the inverse proportion of the lengths, but with a sensible deficiency in the longer pieces.

Experiments 5th and 7th shew the strengths proportional to the breadths and the square of the depth.

Experiments 1st and 7th shew the same thing, compounded with the inverse proportion of the length: the deficiency relative to the length is not so remarkable here.

Experiments 1st and 2d and experiments 5th and 6th shew the increase of strength, by fastening the ends, to be in the proportion of 2 to 3. The theory gives the proportion of 2 to 4. But a difference in the manner of fixing may produce this deviation from the theory, which only supposed them to be held down at places beyond the props, as when a joist is held in the walls, and also rests on two pillars between the walls. (See what is said on this subject in the article ROOF, § 19.) where note, that there is a mistake, when it is said that a beam supported at both ends and loaded in the middle will carry twice as much as if one end were fixed in the wall and the weight suspended at the other end. The reasoning employed there shows that it will carry four times as much.

The chief source of irregularity in such experiments is the fibrous, or rather plated texture of timber. It consists of annual additions, whose cohesion with each other is vastly weaker than that of their own fibres. Let fig. 21. represent the section of a tree, and ABCD, *abcd* the section of two battens that are to be cut out of it for experiment, and let AD and *ad* be the depths, and DC, *dc* the breadths. The batten ABCD will be the strongest, for the same reason that an assemblage of planks set edgewise will form a stronger joist than planks laid above each other like the plates of a coach-spring. Mr Buffon found by many trials that the strength of ABCD was to that of *abcd* (in oak) nearly as 8 to 7. The authors of the different experiments were not careful that their battens had their plates all disposed similarly with respect to the strain. But even with this precaution they would not have afforded sure grounds of computation for large works; for great beams occupy much, if not the whole, of the section of the tree; and from this it has happened that their strength is less than in proportion to that of a small lath or batten. In short, we can trust no experiments but such as have been made on large beams. These must be very rare, for they are most expensive and laborious, and exceed the abilities of most of those who are disposed to study this matter.

But we are not wholly without such authority. Mr Buffon and Mr Du Hamel, two of the first philosophers and mechanicians of the age, were directed by government to make experiments on this subject, and were supplied with ample funds and apparatus. The relation of their experiments is to be found in the Memoirs of the French Academy for 1740, 1741, 1742, 1768; as also in Du Hamel's valuable performances *sur l'Exploitation des Arbres, et sur la Conservation et le Transport de Bois*. We earnestly recommend these dissertations to the perusal of our readers, as containing much useful information relative to the strength of timber,

and the best methods of employing it. We shall here give an abstract of Mr Buffon's experiments.

He relates a great number which he had prosecuted during two years on small battens. He found that the odds of a single layer, or part of a layer, more or less, or even a different disposition of them, had such influence that he was obliged to abandon this method, and to have recourse to the largest beams that he was able to break. The following table exhibits one series of experiments on bars of sound oak, clear of knots, and four inches square. This is a specimen of all the rest.

Column 1st is the length of the bar in feet clear between the supports.

Column 2d is the weight of the bar (the 2d day after it was felled) in pounds. Two bars were tried of each length. Each of the first three pairs consisted of two cuts of the same tree. The one next the root was always found the heaviest, stiffest, and strongest. Indeed Mr Buffon says that this was invariably true, that the heaviest was always the strongest; and he recommends it as a certain (or sure) rule for the choice of timber. He finds that this is always the case when the timber has grown vigorously, forming very thick annual layers. But he also observes that this is only during the advances of the tree to maturity; for the strength of the different circles approaches gradually to equality during the tree's healthy growth, and then it decays in these parts in a contrary order. Our tool-makers assert the same thing with respect to beech: yet a contrary opinion is very prevalent; and wood with a fine, that is, a small grain, is frequently preferred. Perhaps no person has ever made the trial with such minuteness as Mr Buffon, and we think that much deference is due to his opinion.

Column 3d is the number of pounds necessary for breaking the tree in the course of a few minutes.

Column 4th is the inches which it bent down before breaking.

Column 5th is the time at which it broke.

1	2	3	4	5
7	{ 60 56	5350 5275	3.5 4.5	29 22
8	{ 68 63	4600 4500	3.75 4.7	15 13
9	{ 77 71	4100 3950	4.85 5.5	14 12
10	{ 84 82	3625 3600	5.83 6.5	15 15
12	{ 100 98	3050 2925	7. 8.	

The experiments on other sizes were made in the same way. A pair at least of each length and size was taken. The mean results are contained in the following table. The beams were all square, and their sizes in inches are placed at the head of the columns, and their lengths in feet are in the first column.

Strength of
Material.

	4	5	6	7	8	A
7	5312	11525	18950	32200	47649	11525
8	4550	9787	15525	26050	39750	10085
9	4025	8308	13150	22350	32800	8964
10	3612	7125	11250	19475	27750	8068
12	2987	6075	9100	16175	23450	6723
14		5300	7475	13225	19775	5763
16		4350	6362	11000	16375	5042
18		3700	5562	9245	13200	4482
20		3225	4950	8375	11487	4034
22		2975				3667
24		2162				3362
28		1775				2881

Mr Buffon had found by numerous trials that oak-timber lost much of its strength in the course of drying or seasoning; and therefore, in order to secure uniformity, his trees were all felled in the same season of the year, were squared the day after, and tried the third day. Trying them in this green state gave him an opportunity of observing a very curious and unaccountable phenomenon. When the weights were laid briskly on, nearly sufficient to break the log, a very sensible smoke was observed to issue from the two ends with a sharp hissing noise. This continued all the while the tree was bending and cracking. This shows that the log is affected or strained through its whole length; indeed this must be inferred from its bending through its whole length. It also shows us the great effects of the compression. It is a pity Mr Buffon did not take notice whether this smoke issued from the upper or compressed half of the section only, or whether it came from the whole.

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Observations on Mr Buffon's experiments.

We must now make some observations on these experiments, in order to compare them with the theory which we have endeavoured to establish.

Mr Buffon considers the experiments with the 5-inch bars as the standard of comparison, having both extended these to greater lengths, and having tried more pieces of each length.

Our theory determines the relative strength of bars of the same section to be inversely as their lengths. But (if we except the five experiments in the first column) we find a very great deviation from this rule. Thus the 5-inch bar of 28 feet long should have half the strength of that of 14 feet, or 2650; whereas it is but 1775. The bar of 14 feet should have half the strength of that of 7 feet, or 5762; whereas it is but 5300. In like manner, the fourth of 11525 is 2881; but the real strength of the 28-foot bar is 1775. We have added a column A, which exhibits the strength which each of the 5-inch bars ought to have by the theory. This deviation is most distinctly seen in fig. 22. where BK is the scale of lengths, B being at the point 7 of the scale and K at 28. The ordinate CB is = 11525, and the other ordinates DE, GK, &c. are respectively = $\frac{7 \text{ CB}}{\text{Length}}$.

The lines DF, GH, &c. are made = 4350, 1775, &c. expressing the strengths given by experiment. The 10-foot bar and the 24-foot bar are remarkably anomalous. But all are deficient, and the defect has an evident progression from the first to the last. The same thing may be shown of the other columns, and even of the first, though it is very small in that column. It may also be observed in the experiments of Belidor, and in all that we have seen. We cannot doubt therefore of its being a law of nature, depending on the true principles of cohesion and the laws of mechanics.

But it is very puzzling, and we cannot pretend to give a satisfactory explanation of the difficulty. The only effect

which we can conceive the length of a beam to have, is to increase the strain at the section of fracture by employing the intervening beam as a lever. But we do not distinctly see what change this can produce in the mode of action of the fibres in this section, so as either to change their cohesion or the place of its centre of effort: yet something of this kind must happen.

We see indeed some circumstances which must contribute to make a smaller weight sufficient, in Mr Buffon's experiments, to break a long beam than in the exact inverse proportion of its length.

In the first place, the weight of the beam itself augments the strain as much as if half of it were added in form of a weight. Mr Buffon has given the weights of every beam on which he made experiments, which is very nearly 74 pounds per cubic foot. But they are much too small to account for the deviation from the theory. The half weights of the 5-inch beams of 7, 14, and 28 feet length are only 45, 92, and 182 pounds; which makes the real strains in the experiments 11560, 5390, and 1956; which are far from having the proportions of 4, 2, and 1.

Buffon says that healthy trees are universally strongest at the root end; therefore, when we use a longer beam, its middle point, where it is broken in the experiment, is in a weaker part of the tree. But the trials of the 4-inch beams show that the difference from this cause is almost insensible.

The length must have some mechanical influence which the theory we have adopted has not yet explained. It may not however be inadequate to the task. The very ingenious investigation of the elastic curve by James Bernoulli and other celebrated mathematicians is perhaps as refined an application of mathematical analysis as we know. Yet in this investigation it was necessary, in order to avoid almost insuperable difficulties, to take the simplest possible case, viz. where the thickness is exceedingly small in comparison with the length. If the thickness be considerable, the quantities neglected in the calculus are too great to permit the conclusion to be accurate, or very nearly so. Without being able to define the form into which an elastic body of considerable thickness will be bent, we can say with confidence, that in an extreme case, where the compression in the concave side is very great, the curvature differs considerably from the Bernoullian curve. But as our investigation is incomplete and very long, we do not offer it to the reader. The following more familiar considerations will, we apprehend, render it highly probable that the relative strength of beams decreases faster than in the inverse ratio of their length.

The curious observation by Mr Buffon of the vapour which issued with a hissing noise from the ends of a beam of green oak, while it was breaking by the load on its middle, shows that the whole length of the piece was affected: indeed it must be, since it is bent throughout. We have shown above, that a certain definite curvature of a beam of a given form is always accompanied by rupture. Now suppose the beam A of 10 feet long, and the beam B of 20 feet long, bent to the same degree, at the place of their fixure in the wall; the weight which hangs on A is nearly double of that which must hang on B. The form of any portion, suppose 5 feet, of these two beams, immediately adjoining to the wall, is considerably different. At the distance of 5 feet the curvature of A is $\frac{1}{4}$ of its curvature at the wall. The curvature of B in the corresponding point is $\frac{3}{4}$ ths of the same curvature at the wall. Through the whole of the intermediate 5 feet, therefore, the curvature of B is greater than that of A. This must make it weaker throughout. It must occasion the fibres to slide more on each other (that it may acquire this greater curvature), and thus affect their lateral union;

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Probable that the relative strength of beams decreases faster than in the inverse ratio of their length.

Strength of Materials.
 union; and therefore those which are stronger will not assist their weaker neighbours. To this we must add, that in the shorter beams the force with which the fibres are pressed laterally on each other is double. This must impede the mutual sliding of the fibres which we mentioned a little ago; nay, this lateral compression may change the law of longitudinal cohesion (as will readily appear to the reader who is acquainted with Boscovich's doctrines), and increase the strength of the very surface of fracture, in the same way (however inexplicable) as it does in metals when they are hammered or drawn into wire.

The reader must judge how far these remarks are worthy of his attention. The engineer will carefully keep in mind the important fact, that a beam of quadruple length, instead of having $\frac{1}{4}$ th of the strength, has only about $\frac{1}{8}$ th; and the philosopher should endeavour to discover the cause of this diminution, that he may give the artist a more accurate rule of computation.

114 We cannot discover the precise relation between the curvature and the momentum of cohesion.
 Our ignorance of the law by which the cohesion of the particles changes by a change of distance, hinders us from discovering the precise relation between the curvature and the momentum of cohesion; and all we can do is to multiply experiments, upon which we may establish some empirical rules for calculating the strength of solids. Those from which we must reason at present are too few and too anomalous to be the foundation of such an empirical formula.

We may, however, observe, that Mr Buffon's experiments give us considerable assistance in this particular: For if to each of the numbers of the column for the 5-inch beams, corrected by adding half the weight of the beam, we add the constant number 1245, we shall have a set of numbers which are very nearly reciprocals of the lengths. Let 1245 be called c , and let the weight which is known by experiment to be necessary for breaking the 5-inch beam of the

length a be called P . We shall have $\frac{P + c \times a}{l} - c = p$.

Thus the weight necessary for breaking the 7-foot bar is 11560. This added to 1245, and the sum multiplied by

7, gives $P + c \times a = 89635$. Let l be 18; then $\frac{89635}{18}$

$- 1245 = 3725, = p$, which differs not more than $\frac{1}{8}$ th from what experiment gives us. This rule holds equally well in all the other lengths except the 10 and 24 foot beams, which are very anomalous. Such a formula is abundantly exact for practice, and will answer through a much greater variety of length, though it cannot be admitted as a true one; because, in a certain very great length, the strength will be nothing. For other sizes the constant number must change in the proportion of d^3 , or perhaps of p .

115 Relation between the strength and the square of the depth of the section.
 The next comparison which we have to make with the theory is the relation between the strength and the square of the depth of the section. This is made by comparing with each other the numbers in any horizontal line of the table. In making this comparison we find the numbers of the five-inch bars uniformly greater than the rest. We imagine that there is something peculiar to these bars: They are in general heavier than in the proportion of their section, but not so much so as to account for all their superiority. We imagine that this set of experiments, intended as a standard for the rest, has been made at one time, and that the season has had a considerable influence. The fact however is, that if this column be kept out, or uniformly diminished about $\frac{1}{8}$ th in their strength, the different sizes will deviate very little from the ratio of the square of the depth, as determined by theory. There is however a small deficiency in the bigger beams.

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 We have been thus anxious in the examination of these experiments, because they are the only ones which have been related in sufficient detail, and made on a proper scale for giving us data from which we can deduce confidential maxims for practice. They are so troublesome and expensive that we have little hopes of seeing their number greatly increased; yet surely our navy board would do an unspeakable service to the public by appropriating a fund for such experiments under the management of some man of science.

116 Proportion between the absolute cohesion and the relative strength.
 There remains another comparison which is of chief importance, namely, the proportion between the ABSOLUTE COHESION and the RELATIVE STRENGTH. It may be guessed, from the very nature of the thing, that this must be very uncertain. Experiments on the absolute strength must be confined to very small pieces, by reason of the very great forces which are required for tearing them asunder. The values therefore deduced from them must be subject to great inequalities. Unfortunately we have got no detail of any experiments; all that we have to depend on is two passages of Muschenbroek's *Essais de Physique*; in one of which he says that a piece of sound oak $\frac{27}{100}$ ths of an inch square is torn asunder by 1150 pounds; and in the other, that an oak plank 12 inches broad and 1 thick will just suspend 189163 pounds. These give for the cohesion of an inch square 15,755 and 15,763 pounds. Bouguer, in his *Traité du Navire*, says that it is very well known that a rod of sound oak $\frac{1}{4}$ th of an inch square will be torn asunder by 1000 pounds. This gives 16000 for the cohesion of a square inch. We shall take this as a round number, easily used in our computations. Let us compare this with Mr Buffon's trials of beams four inches square.

The absolute cohesion of this section is $16,000 \times 16 = 256,000$. Did every fibre exert its whole force in the instant of fracture, the momentum of cohesion would be the same as if it had all acted at the centre of gravity of the section at 2 inches from the axis of fracture, and is therefore 512000. The 4-inch beam, 7 feet long, was broken by 5312 pounds hung on its middle. The half of this, or 2656 pounds, would have broken it, if suspended at its extremity, projecting $3\frac{1}{2}$ feet or 42 inches from a wall. The momentum of this strain is therefore $2656 \times 42 = 111552$. Now this is in equilibrio with the actual momentum of cohesion, which is therefore 111552, instead of 512000. The strength is therefore diminished in the proportion of 512000 to 111552, or very nearly of 4.59 to 1.

As we are quite uncertain as to the place of the centre of effort, it is needless to consider the full cohesion as acting at the centre of gravity, and producing the momentum 512,000; and we may convert the whole into a simple multiplier m of the length, and say, as m times the length is to the depth, so is the absolute cohesion of the section to the relative strength. Therefore let the absolute cohesion of a square inch be called f , the breadth b , the depth d , and the length l (all in inches), the relative strength, or the external force p , which balances it, is $\frac{f b d^2}{9,18 l}$, or in round numbers $\frac{f b d^2}{9 l}$; for $m = 2 \times 4.59$.

This great diminution of strength cannot be wholly accounted for by the inequality of the cohesive forces exerted in the instant of fracture; for in this case we know that the centre of effort is at $\frac{1}{4}d$ of the height in a rectangular section (because the forces really exerted are as the extensions of the fibres). The relative strength would be $\frac{f b d^2}{3 l}$, and p would have been 8127 instead of 2656.

We must ascribe this diminution (which is three times greater than that produced by the inequality of the cohesive

Strength of Materials. (five forces) to the compression of the under part of the beam; and we must endeavour to explain in what manner this compression produces an effect which seems so little explicable by such means.

As we have repeatedly observed, it is a matter of nearly universal experience that the forces *actually* exerted by the particles of bodies, when stretched or compressed, are very nearly in the proportion of the distances to which the particles are drawn from their natural positions. Now, altho' we are certain that, in enormous compressions, the forces increase faster than in this proportion, this makes no sensible change in the present question, because the body is broken before the compressions have gone so far; nay, we imagine that the compressed parts are crippled in most cases even before the extended parts are torn asunder. Muschenbroek asserts this with great confidence with respect to oak, on the authority of his own experiments. He says, that although oak will suspend half as much again as fir, it will not support, as a pillar, two-thirds of the load which fir will support in that form.

We imagine therefore that the mechanism in the *present* case is nearly as follows:

Let the beam DCK Δ (fig. 23.) be loaded at its extremity with the weight P, acting in the direction KP perpendicular to DC. Let D Δ be the section of fracture. Let DA be about $\frac{1}{3}$ d of D Δ . A will be the particle or fibre which is neither extended nor compressed. Make $\Delta s : D d = DA : A \Delta$. The triangles DA d, $\Delta A s$, will represent the accumulated attracting and repelling forces. Make AI and $A i = \frac{1}{3} DA$ and $\frac{1}{3} \Delta A$. The point I will be that to which the full cohesion D d or f of the particles in AD must be applied, so as to produce the same momentum which the variable forces at I, D, &c. really produce at their several points of application. In like manner, i is the centre of similar effort of the repulsive forces excited by the compression between A and Δ , and it is the real fulcrum of a bended lever I i K, by which the whole effect is produced. The effect is the same as if the full cohesion of the stretched fibres in AD were accumulated in I, and the full repulsion of all the compressed fibres in A Δ were accumulated in i. The forces which are balanced in the operation are the weight P, acting by the arm k i, and the full cohesion of AD acting by the arm I i. The forces exerted by the compressed fibres between A and Δ only serve to give support to the lever, that it may exert its strain.

We imagine that this does not differ much from the real procedure of nature. The position of the point A may be different from what we have deduced from Mr Buffon's experiments, compared with Muschenbroek's value of the absolute cohesion of a square inch. If this last should be only 12000, DA must be greater than we have here made it, in the proportion of 12000 to 16000. For I i must still be made $= \frac{1}{3} A \Delta$, supposing the forces to be proportional to the extensions and compressions. There can be no doubt that a part only of the cohesion of D Δ operates in resisting the fracture in all substances which have any compressibility; and it is confirmed by the experiments of Mr Du Hamel on willow, and the inferences are by no means confined to that species of timber. We say therefore, that when the beam is broken, the cohesion of AD alone is exerted, and that each fibre exerts a force proportional to its extension; and the accumulated momentum is the same as if the full cohesion of AD were acting by the lever I i $= \frac{1}{3}$ d of D Δ .

It may be said, that if only $\frac{1}{3}$ d of the cohesion of oak be exerted, it may be cut $\frac{2}{3}$ ds through without weakening it. But this cannot be, because the cohesion of the whole is employed in preventing the lateral slide so often mentioned.

We have no experiments to determine that it may not be cut through $\frac{1}{3}$ d without loss of its strength. Strength of Materials.

This must not be considered as a subject of mere speculative curiosity: It is intimately connected with all the practical uses which we can make of this knowledge; for it is almost the only way that we can learn the compressibility of timber. Experiments on the direct cohesion are indeed difficult, and exceedingly expensive if we attempt them in large pieces. But experiments on compression are almost impracticable. The most instructive experiments would be, first to establish, by a great number of trials, the transverse force of a modern batten; and then to make a great number of trials of the diminution of its strength, by cutting it through on the concave side. This would very nearly give us the proportion of the cohesion which really operates in resisting fractures. Thus if it be found that one-half of the beam may be cut on the under side without diminution of its strength (taking care to drive in a slice of harder wood), we may conclude that the point A is at the middle, or somewhat above it.

Much lies before the curious mechanic, and we are as yet very far from a scientific knowledge of the strength of timber.

In the mean time, we may derive from these experiments of Buffon a very useful practical rule, without relying on any value of the absolute cohesion of oak. We see that the strength is nearly as the breadth, as the square of the depth, and as the inverse of the length. It is most convenient to measure the breadth and depth of the beam in inches, and its length in feet. Since, then, a beam four inches square and seven feet between the supports is broken by 5312 pounds, we must conclude that a batten one inch square and one foot between the supports will be broken by 581 pounds. Then the strength of any other beam of oak, or the weight which will just break it when hung on its middle, is $581 \frac{b d^2}{l}$. 117
A useful practical rule may be deduced from Mr Buffon's experiments.

But we have seen that there is a very considerable deviation from the inverse proportion of the lengths, and we must endeavour to accommodate our rule to this deviation. We found, that by adding 1245 to each of the ordinates or numbers in the column of the five-inch bars, we had a set of numbers very nearly reciprocal of the lengths; and if we make a similar addition to the other columns in the proportion of the cubes of the fixes, we have nearly the same result. The greatest error (except in the case of experiments which are very irregular) does not exceed $\frac{1}{3}$ th of the whole. Therefore, for a radical number, add to the 5312 the number 640, which is to 1245 very nearly as 4³ to 5³. This gives 5952. The 64th of this is 93, which corresponds to a bar of one inch square and seven feet long. Therefore 93×7 will be the reciprocal corresponding to a bar of one foot. This is 651. Take from this the present empirical

correction, which is $\frac{b 40}{b 4}$, or 10, and there remains 641 for the strength of the bar. This gives us for a general rule

$$p = 651 \frac{b d^2}{l} - 10 b d^2.$$

Example. Required the weight necessary to break an oak beam eight inches square and 20 feet between the props, $p = 651 \times \frac{8 \times 8^2}{20} - 10 \times 8 \times 8^2$. This is 11545, whereas the experiment gives 11487. The error is very small indeed. The rule is most deficient in comparison with the five-inch bars, which we have already said appear stronger than the rest.

Strength of
Materials.

The following process is easily remembered by such as are not algebraists.

Multiply the breadth in inches twice by the depth, and call this product f . Multiply f by 651, and divide by the length in feet. From the quotient take 10 times f . The remainder is the number of pounds which will break the beam.

We are not sufficiently sensible of our principles to be confident that the correction 10 f should be in the proportion of the section, although we think it most probable. It is quite empirical, founded on Buffon's experiments. Therefore the safe way of using this rule is to suppose the beam square, by increasing or diminishing its breadth till equal to the depth. Then find the strength by this rule, and diminish or increase it for the change which has been made in its breadth. Thus, there can be no doubt that the strength of the beam given as an example is double of that of a beam of the same depth and half the breadth.

The reader cannot but observe that all this calculation relates to the very greatest weight which a beam will bear for a very few minutes. Mr Buffon uniformly found that two-thirds of this weight sensibly impaired its strength, and frequently broke it at the end of two or three months. One-half of this weight brought the beam to a certain bend, which did not increase after the first minute or two, and may be borne by the beam for any length of time. But the beam contracted a bend, of which it did not recover any considerable portion. One-third seemed to have no permanent effect on the beam; but it recovered its rectilinear shape completely, even after having been loaded several months, provided that the timber was seasoned when first loaded; that is to say, one-third of the weight which would quickly break a seasoned beam, or one-fourth of what would break one just felled, may lie on it for ever without giving the beam a sett.

We have no detail of experiments on the strength of other kinds of timber: only Mr Buffon says, that fir has about $\frac{6}{10}$ ths of the strength of oak; Mr Parent makes it $\frac{1}{2}$ ths; Emerson, $\frac{2}{3}$ ds, &c.

We have been thus minute in our examination of the mechanism of this transverse strain, because it is the greatest to which the parts of our machines are exposed. We wish to impress on the minds of artists the necessity of avoiding this as much as possible. They are improving in this respect, as may be seen by comparing the centres on which stone arches of great span are now turned with those of former times. They were formerly a load of mere joists resting on a multitude of posts, which obstructed the navigation, and were frequently losing their shape by some of the posts sinking into the ground. Now they are more generally trusses, where the beams abutt on each other, and are relieved from transverse strains. But many performances of eminent artists are still very injudiciously exposed to cross strains. We may instance one which is considered as a fine work, viz. the bridge at Walton on Thames. Here every beam of the great arch is a joist, and it hangs together by framing. The finest piece of carpentry that we have seen is the centre employed in turning the arches of the bridge at Orleans, described by Perronet. In the whole there is not one cross strain. The beam, too, of Hornblower's steam-engine, described in that article, is very scientifically constructed.

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Strain produced by
twisting.

IV. The last species of strain which we are to examine is that produced by twisting. This takes place in all axles which connect the working parts of machines.

Although we cannot pretend to have a very distinct conception of that modification of the cohesion of a body by which it resists this kind of strain, we can have no doubt that, when all the particles act alike, the resistance must be

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proportional to the number. Therefore if we suppose the two parts ABCD, ABFE (fig. 24.), of the body EFCD to be of insuperable strength, but cohering more weakly in the common surface AB, and that one part ABCD is pushed laterally in the direction AB, there can be no doubt that it will yield only there, and that the resistance will be proportional to the surface.

Strength of
Materials.
119
The resist-
ance must
be propor-
tional to
the number
of particles.

In like manner, we can conceive a thin cylindrical tube, of which KAH (fig. 25.) is the section, as cohering more weakly in that section than anywhere else. Suppose it to be grasped in both hands, and the two parts twisted round the axis in opposite directions, as we would twist the two joints of a flute, it is plain that it will first fail in this section, which is the circumference of a circle, and the particles of the two parts which are contiguous to this circumference will be drawn from each other laterally. The total resistance will be as the number of equally resisting particles, that is, as the circumference (for the tube being supposed very thin, there can be no sensible difference between the dilatation of the external and internal particles). We can now suppose another tube within this, and a third within the second, and so on till we reach the centre. If the particles of each ring exerted the same force (by suffering the same dilatation in the direction of the circumference), the resistance of each ring of the section would be as its circumference and its breadth (supposed indefinitely small), and the whole resistance would be as the surface; and this would represent the resistance of a solid cylinder. But when a cylinder is twisted in this manner by an external force applied to its circumference, the external parts will suffer a greater circular extension than the internal; and it appears that this extension (like the extension of a beam strained transversely) will be proportional to the distance of the particles from the axis. We cannot say that this is demonstrable, but we can assign no proportion that is more probable. This being the case, the forces simultaneously exerted by each particle will be as its distance from the axis. Therefore the whole force exerted by each ring will be as the square of its radius, and the accumulated force actually exerted will be as the cube of the radius; that is, the accumulated force exerted by the whole cylinder, whose radius is CA, is to the accumulated force exerted at the same time by the part whose radius is CE, as CA³ to CE³.

The whole cohesion now exerted is just two-thirds of what it would be if all the particles were exerting the same attractive forces which are just now exerted by the particles in the external circumference. This is plain to any person in the least familiar with the fluxionary calculus. But such as are not may easily see it in this way.

Let the rectangle ACca be set upright on the surface of the circle along the line CA, and revolve round the axis Cc. It will generate a cylinder whose height is Cc or Aa, and having the circle KAH for its base. If the diagonal Ca be supposed also to revolve, it is plain that the triangle cCa will generate a cone of the same height, and having for its base the circle described by the revolution of ca, and the point C for its apex. The cylindrical surface generated by Aa will express the whole cohesion exerted by the circumference AHK, and the cylindrical surface generated by Ec will represent the cohesion exerted by the circumference ELM, and the solid generated by the triangle CAa will represent the cohesion exerted by the whole circle AHK, and the cylinder generated by the rectangle ACca will represent the cohesion exerted by the same surface if each particle had suffered the extension Aa.

Now it is plain, in the first place, that the solid generated by the triangle cEC is to that generated by aAC as EC³ to AC³. In the next place, the solid generated by

E

aAC

Strength of
Materials.

AC is two-thirds of the cylinder, because the cone generated by cCa is one-third of it.

We may now suppose the cylinder twisted till the particles in the external circumference lose their cohesion. There can be no doubt that it will now be wrenched asunder, all the inner circles yielding in succession. Thus we obtain one useful information, viz. that a body of homogeneous texture resists a *simple twist* with two-thirds of the force with which it resists an attempt to force one part laterally from the other, or with one-third part of the force which will cut it asunder by a square-edged tool. For to drive a square-edged tool through a piece of lead, for instance, is the same as forcing a piece of the lead as thick as the tool laterally away from the two pieces on each side of the tool. Experiments of this kind do not seem difficult, and they would give us very useful information.

120
With what
force a bo-
dy of a ho-
mogeneous
texture re-
sists a sim-
ple twist.

121
The forces
exerted in
breaking
two cylin-
ders are as
the squares
of the di-
ameters.

When two cylinders AHK and BNO are wrenched asunder, we must conclude that the external particles of each are just put beyond their limits of cohesion, are equally extended, and are exerting equal forces. Hence it follows, that in the instant of fracture the sum total of the forces actually exerted are as the squares of the diameters.

For drawing the diagonal Ce , it is plain that $Ee = Aa$, expresses the distension of the circumference ELM, and that the solid generated by the triangle CEe expresses the cohesion exerted by the surface of the circle ELM, when the particles in the circumference suffer the extension Ee equal to Aa . Now the solids generated by CAa and CEe being respectively two-thirds of the corresponding cylinders, are as the squares of the diameters.

122
Relative
Strength of
the section
to the ex-
ternal force
employed
to break it.

Having thus ascertained the real strength of the section, and its relation to its absolute lateral strength, let us examine its strength relative to the external force employed to break it. This examination is very simple in the case under consideration. The straining force must act by some lever, and the cohesion must oppose it by acting on some other lever. The centre of the section may be the neutral point, whose position is not disturbed.

Let F be the force exerted laterally by an exterior particle. Let a be the radius of the cylinder, and x the indeterminate distance of any circumference, and x the indefinitely small interval between the concentric arches; that is, let x be the breadth of a ring and x its radius. The forces being as the extensions, and the extensions as the distances from the axis, the cohesion actually exerted at any part of any ring will be $f \frac{x^2}{a}$. The force exerted by the whole ring (being as the circumference or as the radius) will be $f \frac{x^2}{a}$. The momentum of cohesion of a ring, being as the force multiplied by its lever, will be $f \frac{x^3}{a}$. The accumulated momentum will be the sum or fluent of $f \frac{x^3}{a}$; that is, when $x = a$, it will be $\frac{1}{4} f \frac{a^4}{a} = \frac{1}{4} f a^3$.

123
The resist-
ance of the
axle is as
the cube of
its diam-
eter.

Hence we learn that the strength of an axle, by which it resists being wrenched asunder by a force acting at a given distance from the axis, is as the cube of its diameter.

But farther, $\frac{1}{4} f a^3$ is $= f a^2 \times \frac{1}{4} a$. Now $f a^2$ represents the full lateral cohesion of the section. The momentum therefore is the same as if the full lateral cohesion were accumulated at a point distant from the axis by $\frac{1}{4}$ th of the radius or $\frac{1}{8}$ th of the diameter of the cylinder.

Therefore let F be the number of pounds which measures

the lateral cohesion of a circular inch, d the diameter of the cylinder in inches, and l the length of the lever by which the straining force p is supposed to act, we shall have $F \times \frac{1}{8} d^3 = p l$, and $F \frac{d^3}{8 l} = p$.

We see in general that the strength of an axle, by which it resists being wrenched asunder by twisting, is as the cube of its diameter.

We see also that the internal parts are not acting so powerfully as the external. If a hole be bored out of the axle of half its diameter, the strength is diminished only $\frac{1}{8}$ th, while the quantity of matter is diminished $\frac{1}{8}$ th. Therefore hollow axles are stronger than solid ones containing the same quantity of matter. Thus let the diameter be 5 and that of the hollow 4: then the diameter of another solid cylinder having the same quantity of matter with the tube is 3. The strength of the solid cylinder of the diameter 5 may be expressed by 5³ or 125. Of this the internal part (of the diameter 4) exerts 64; therefore the strength of the tube is 125—64, = 61. But the strength of the solid axle of the same quantity of matter and diameter 3 is 3³, or 27, which is not half of that of the tube.

Engineers, therefore, have of late introduced this improvement in their machines, and the axles of cast iron are all made hollow when their size will admit it. They have the additional advantage of being much stiffer, and of affording much better fixure for the flanches, which are used for connecting them with the wheels or levers by which they are turned and strained. The superiority of strength of hollow tubes over solid cylinders is much greater in this kind of strain than in the former or transverse. In this last case the strength of this tube would be to that of the solid cylinder of equal weight as 61 to 32 $\frac{1}{2}$ nearly.

The apparatus which we mentioned on a former occasion for trying the lateral strength of a square inch of solid matter, enabled us to try this theory of twist with all desirable accuracy. The bar which hung down from the pin in the former trials was now placed in a horizontal position, and loaded with a weight at the extremity. Thus it acted as a powerful lever, and enabled us to wrench asunder specimens of the strongest materials. We found the results perfectly conformable to the theory, in as far as it determined the proportional strength of different sizes and forms: but we found the ratio of the resistance to twisting to the simple lateral resistance considerably different; and it was some time before we discovered the cause.

We had here taken the simplest view that is possible of the action of cohesion in resisting a twist. It is frequently exerted in a very different way. When, for instance, an iron axle is joined to a wooden one by being driven into one end of it, the extensions of the different circles of particles are in a very different proportion. A little consideration will show that the particles in immediate contact with the iron axle are in a state of violent extension; so are the particles of the exterior surface of the wooden part, and the intermediate parts are less strained. It is almost impossible to assign the exact proportion of the cohesive forces exerted in the different parts. Numberless cases can be pointed out where parts of the axle are in a state of compression, and where it is still more difficult to determine the state of the other particles. We must content ourselves with the deductions made from this simple case, which is fortunately the most common. In the experiments just now mentioned the centre of the circle is by no means the neutral point, and it is very difficult to ascertain its place: but when this consideration occurred to us, we easily freed the experiments from this uncertainty, by extending the lever to both sides, and by means of a pulley applied equal force to

Strength of
Materials.

124
Hollow
axles more
proper than
solid ones.

125
And now
generally
used.

126
The ratio
of resist-
ance to
twisting
to the sim-
ple lateral
resistance
appears
different.

127
But when
the experi-
ment was
altered, it
was exact-
ly the same.

Strength of Materials
||
Stretto.
128
Experiments on chalk, clay, and wax, satisfactory; but those on timber irregular.

to each arm, acting in opposite directions. Thus the centre became the neutral point, and the resistance to twist was found to be $\frac{2}{3}$ ds of the simple lateral strength.

We beg leave to mention here that our success in these experiments encouraged us to extend them much farther. We hoped by these means to discover the absolute cohesion of many substances, which would have required an enormous apparatus and a most unmanageable force to tear them asunder directly. But we could reason with confidence from the resistance to twist (which we could easily measure), provided that we could ascertain the proportion of the direct and the lateral strengths. Our experiments on chalk, finely prepared clay, and white bees-wax (of one melting and one temperature), were very consistent and satisfactory. But we have hitherto found great irregularities in this proportion in bodies of a fibrous texture like timber. These are the most important cases, and we still hope to be able to accomplish our project, and to give the public some valuable information. This being our sole object, it was our duty to mention the method which promises success, and thus excite others to the task; and it will be no mortification to us to be deprived of the honour of being the first who thus adds to the stock of experimental knowledge.

When the matter of the axle is of the most simple texture, such as that of metals, we do not conceive that the length of the axle has any influence on the fracture. It is otherwise if it be of a fibrous texture like timber: the fibres are bent before breaking, being twisted into spirals like a cork-screw. The length of the axle has somewhat of the influence of a lever in this case, and it is easier wrenched asunder if long. Accordingly we have found it so; but we have not been able to reduce this influence to calculation.

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Concluding remarks.

Our readers are requested to accept of these endeavours to communicate information on this important and difficult subject. We are duly sensible of their imperfection, but flatter ourselves that we have in many instances pointed out the method which must be pursued for improving our knowledge on this subject; and we have given the English reader a more copious list of experiments on the strength of materials than he will meet with in our language. Many useful deductions might be made from these premises respecting the manner of disposing and combining the strength of materials in our structures. The best form of joints, mortises, tenons, scarphs; the rules for joggling, tabling, faying, fishing, &c. practised in the delicate art of mast-making, are all founded on this doctrine; but the discussion of these would be equivalent to writing a complete treatise of carpentry. We hope that this will be executed by some intelligent mechanic, for there is nothing in our language on this subject but what is almost contemptible; yet there is no mechanic art that is more susceptible of scientific treatment. Such a treatise, if well executed, could not fail of being well received by the public in this age of mechanical improvement.

STRENGTHENERS, or CORROBORANTS, such medicines as add to the bulk and firmness of the solids; and such are all agglutinant and astringent medicines. See MATERIA MEDICA, p. 649. art. 6.

STRETCHING, in navigation, is generally understood to imply the progression of a ship under a great surface of sail, when close-hauled. The difference between this term and *standing*, consists apparently in the quantity of sail; which in the latter may be very moderate; but stretching generally signifies excess: as, we saw the enemy at day break stretching to the southward under a croud of sail, &c. *Falconer*.

STRETTO, in Italian music, is sometimes used to signify that the measure is to be short and concise, and consequently quick. In this sense it stands opposed to LARGO.

STRIATED LEAF, among botanists, one that has a number of longitudinal furrows on its surface.

STRIKE, a measure of capacity, containing four bushels. Also an instrument used in measuring corn.

STRIX, the owl, in ornithology, a genus belonging to the order of *accipitres*. The bill is hooked, but has no cere or wax; the nostrils are covered with setaceous feathers; the head is very large, as are also the ears and eyes; and the tongue is bifid. There are 46 species; the most remarkable are,

1. The *bubo*, or great-eared owl, in size is almost equal to an eagle. Irides bright yellow; head and whole body finely varied with lines, spots, and specks of black, brown, cinereous, and ferruginous. Wings long; tail short, marked with dusky bars. Legs thick, covered to the very end of the toes with a close and full down of a testaceous colour. Claws great, much hooked, and dusky.—It has been shot in Scotland and in Yorkshire. It inhabits inaccessible rocks and desert places; and preys on hares and feathered game. Its appearance in cities was deemed an unlucky omen; Rome itself once underwent a lustration because one of them strayed into the capitol. The ancients had them in the utmost abhorrence; and thought them, like the screech-owls, the messengers of death. Pliny styles it *bubo funebris*, and *noctis monstrum*.

Solaque culminibus ferali carmine bubo

Sape queri et longas in fletum ducere voces. VIRGIL.

Perch'd on the roof, the bird of night complains,
In lengthen'd shrieks and dire funereal strains.

2. The *otus*, or long-eared owl, is found, though not frequently, in the north of England, in Cheshire, and in Wales. Mr Hasselquist saw it alive in Cairo, and it is not unfrequent all over Egypt. Its weight, according to Dr Latham, is nine ounces; the length 14 inches and a half; the breadth 34; the irides are of a bright yellow; the bill black; the breast and belly are of a dull yellow, marked with slender brown strokes pointing downwards; the thighs and vent-feathers of the same colour, but unspotted. The back and coverts of the wings are varied with deep brown and yellow; the quill-feathers of the same colour, but near the ends of the outmost is a broad bar of red; the tail is marked with dusky and reddish bars, but beneath appears ash-coloured; the horns or ears are about an inch long, and consist of six feathers variegated with yellow and black; the feet are feathered down to the claws.

3. The *brachyotos*, or short-eared owl, is 14 inches long; three feet broad; the head is small and hawk-like; the bill is dusky; weight 14 ounces; the circle of feathers that immediately surrounds the eyes is black; the larger circle white, terminated with tawny and black; the feathers on the head, back, and coverts of the wings, are brown, edged with pale dull yellow; the breast and belly are of the same colour, marked with a few long narrow streaks of brown pointing downwards; the quill-feathers are dusky, barred with red; the tail is of a very deep brown, adorned on each side of the shaft of the four middle feathers with a yellow circle which contains a brown spot; the tip of the tail is white. The horns of this species are very small, and each consists of only a single feather; these it can raise or depress at pleasure; and in a dead bird are with difficulty discovered. This kind is scarcer than the former; both are solitary birds, avoiding inhabited places. These species may be called *long-winged owls*; the wings when closed reaching beyond the end of the tail; whereas in the common kinds they fall short of it.—This is a bird of passage, and has been observed to visit Lincolnshire in the beginning of October, and

Strix.

to retire early in the spring; so probably, as it performs its migrations with the woodcock, its summer-retreat is Norway. During day it lies hid in long old grass; when disturbed, it seldom flies far, but will light, and sit looking at one, at which time the horns may be seen very distinctly. It has not been observed to perch on trees like other owls; it usually flies in search of prey in cloudy hazy weather. Farmers are fond of seeing these birds in the fields, as they clear them from mice. It is found frequently on the hill of Hoy in the Orkneys, where it flies about and preys by day like a hawk. It is found also, as we mentioned before, in Lancashire, which is a hilly and woody country; and in New England and Newfoundland.

4. The *flammea*, or common white owl. The elegant plumage of this bird makes amends for the uncouthness of its form: a circle of soft white feathers surround the eyes. The upper part of the body, the coverts, and secondary feathers of the wings, are of a fine pale yellow: on each side of the shafts are two grey and two white spots placed alternate: the exterior sides of the quill-feathers are yellow; the interior white, marked on each side with four black spots: the lower side of the body is wholly white; the interior sides of the feathers of the tail are white; the exterior marked with some obscure dusky bars; the legs are feathered to the feet: the feet are covered with short hairs: the edge of the middle claw is ferrated. The usual weight is 11 ounces; its length 14 inches; its breadth 3 feet.—This species is almost domestic; inhabiting, for the greatest part of the year, barns, hay-lofts, and other out houses; and is as useful in clearing those places from mice as the congenial cat: towards twilight it quits its perch, and takes a regular circuit round the fields, skimming along the ground in quest of field-mice, and then returns to its usual residence: in the breeding-season it takes to the eaves of churches, holes in lofty buildings, or hollows of trees. During the time the young are in the nest, the male and female alternately sally out in quest of food, make their circuit, beat the fields with the regularity of a spaniel, and drop instantly on their prey in the grass. They very seldom stay out above five minutes; return with their prey in their claws; but as it is necessary to shift it into their bill, they always alight for that purpose on the roof, before they attempt to enter their nest. This species does not hoot; but snores and hisses in a violent manner; and while it flies along will often scream most tremendously. Its only food is mice. As the young of these birds keep their nest for a great length of time, and are fed even long after they can fly, many hundreds of mice will scarcely suffice to supply them with food. Owls cast up the bones, fur, or feathers of their prey, in form of small pellets, after they have devoured it, in the same manner as hawks do. A gentleman, on grubbing up an old pollard-ash that had been the habitation of owls for many generations, found at the bottom many bushels of this rejected stuff. Some owls, when they are satisfied, hide the remainder of their meat like dogs.

5. The *stridula*, or tawny owl. The female of this species weighs 19 ounces; the length is 15 inches; the breadth 2 feet 8 inches; the irides are dusky; the ears in this, as in all owls, very large; and their sense of hearing very exquisite. The colour of this kind is sufficient to distinguish it from every other: that of the back, head, coverts of the wings, and on the scapular feathers, being a fine tawny red, elegantly spotted and powdered with the black or dusky spots of various sizes: on the coverts of the wings and on the scapulars are several large white spots: the coverts of the tail are tawny, and quite free from any marks: the tail

is variously blotched, barred and spotted with pale red and black; in the two middle feathers the red predominates: the breast and belly are yellowish, mixed with white, and marked with narrow black strokes pointing downwards: the legs are covered with feathers down to the toes.—This is a hardier species than the former; and the young will feed on any dead thing, whereas those of the white owl must have a constant supply of fresh meat. It is the *strix* of Aldrovandus, and what we call the *screech-owl*; to which the folly of superstition had given the power of pre-faging death by its cries. The ancients believed that it sucked the blood of young children: a fact some think not incredible; for Hasselquist describes a species found in Syria, which frequently in the evening flies in at the windows, and destroys the helpless infant.

*Nocte volant, puerosque petunt nutricis egentes,
Et vitiant cuneis corpora rapta suis.
Carpere dicuntur laetitia viscera rostris,
Et plenum poto sanguine guttur habent.
Est illis strigibus nomen, sed nominis hujus
Causa quod horrenda stridere nocte solent.* Ovid Fast. vi. 135.

6. The *ulula*, or brown owl, agrees with the former in its marks; differing only in the colours: in this, the head, wings, and back, are of a deep brown, spotted with black in the same manner as the former: the coverts of the wings and the scapulars are adorned with similar white spots: the exterior edges of the four first quill-feathers in both are ferrated: the breast in this is of a very pale ash-colour mixed with tawny, and marked with oblong jagged spots: the feet too are feathered down to the very claws: the circle round the face is ash-coloured, spotted with brown.—Both these species inhabit woods, where they reside the whole day: in the night they are very clamorous; and when they hoot, their throats are inflated to the size of an hen's egg. In the dusk they approach our dwellings; and will frequently enter pigeon-houses, and make great havoc in them. They destroy numbers of little leverets, as appears by the legs frequently found in their nests. They also kill abundance of moles, and skin them with as much dexterity as a cook does a rabbit. They build in hollow trees or ruined edifices; lay four eggs, of an elliptic form, and of a whitish colour.

7. The *passerina*, or little owl, is very rare in England; it is sometimes found in Yorkshire, Flintshire, and also near London: in size it scarcely exceeds a thrush, though the fulness of its plumage makes it appear larger: the irides are of a light yellow; the bill of a paper-colour; the feathers that encircle the face are white tipped with black; the head brown, spotted with white; on the breast is a mixture of white and brown; the belly is white, marked with a few brown spots; the tail of the same colour with the back; in each feather barred with white; in each adorned with circular white spots, placed opposite to one another on both sides of the shaft; the legs and feet are covered with feathers down to the claws.—The Italians make use of this owl to decoy small birds to the limed twig; the method of which is exhibited in Olina's *Uccelliera*, p. 65. Mr Stuart, author of the *Antiquities of Athens*, informed Mr Pennant, that this species of owl was very common in Attica; that they were birds of passage, and appeared there in the beginning of April in great numbers; that they bred there; and that they retired at the same time as the storks, whose arrival they a little preceded.

8. The spectacle owl of Cayenne, which is accurately described by Dr Latham, is 21 inches in length: the upper parts of the body are of a reddish colour; the lower parts

Strix.

STRENGTH of MATERIALS.

Plate CCCCLXXIV.

Fig. 1.

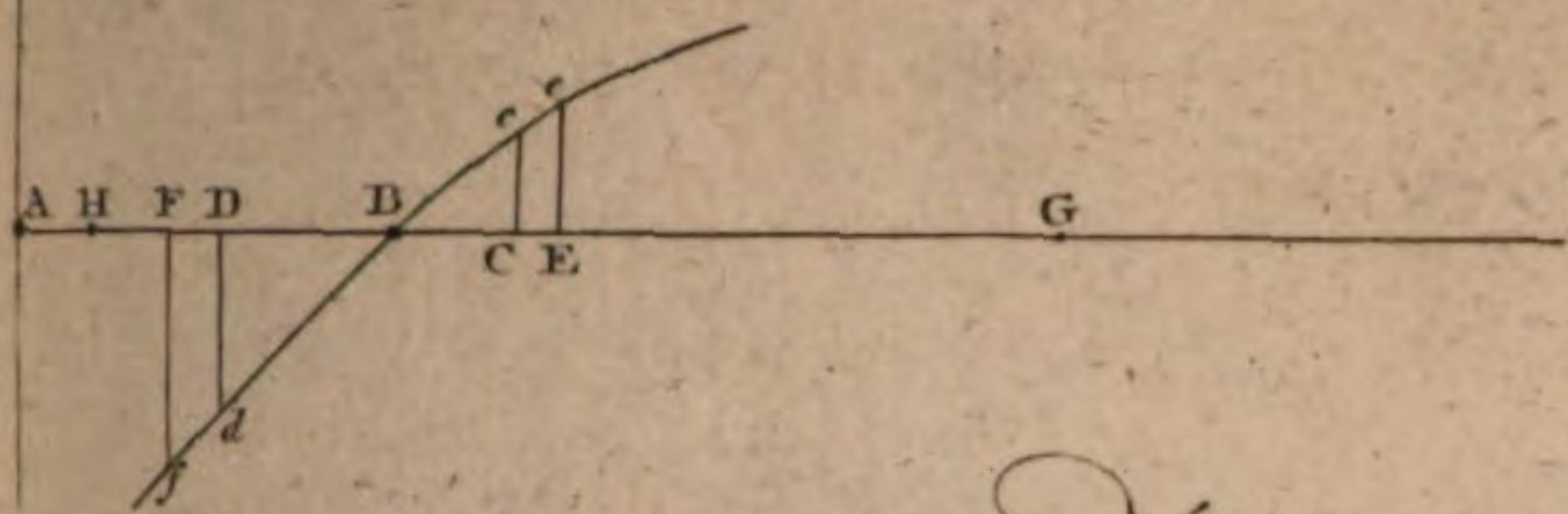


Fig. 2.

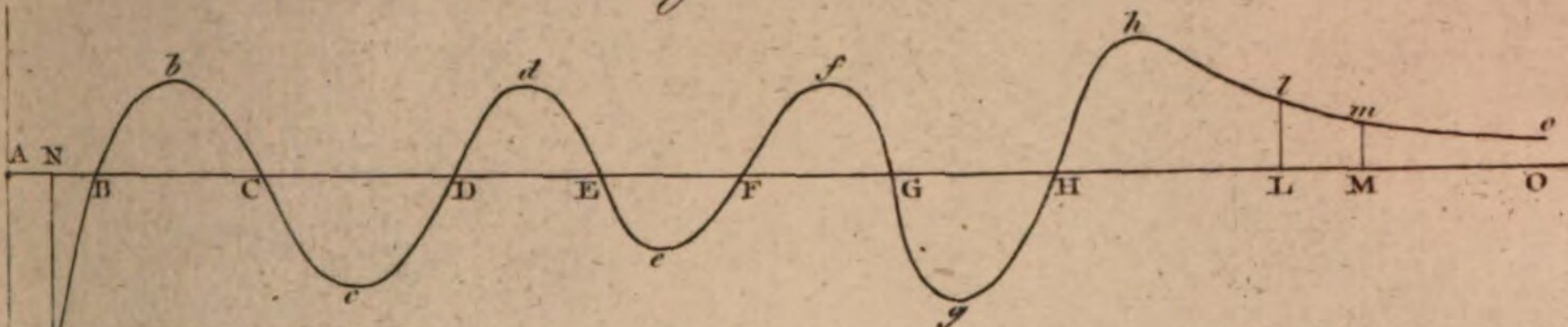


Fig. 5. N^o 1.

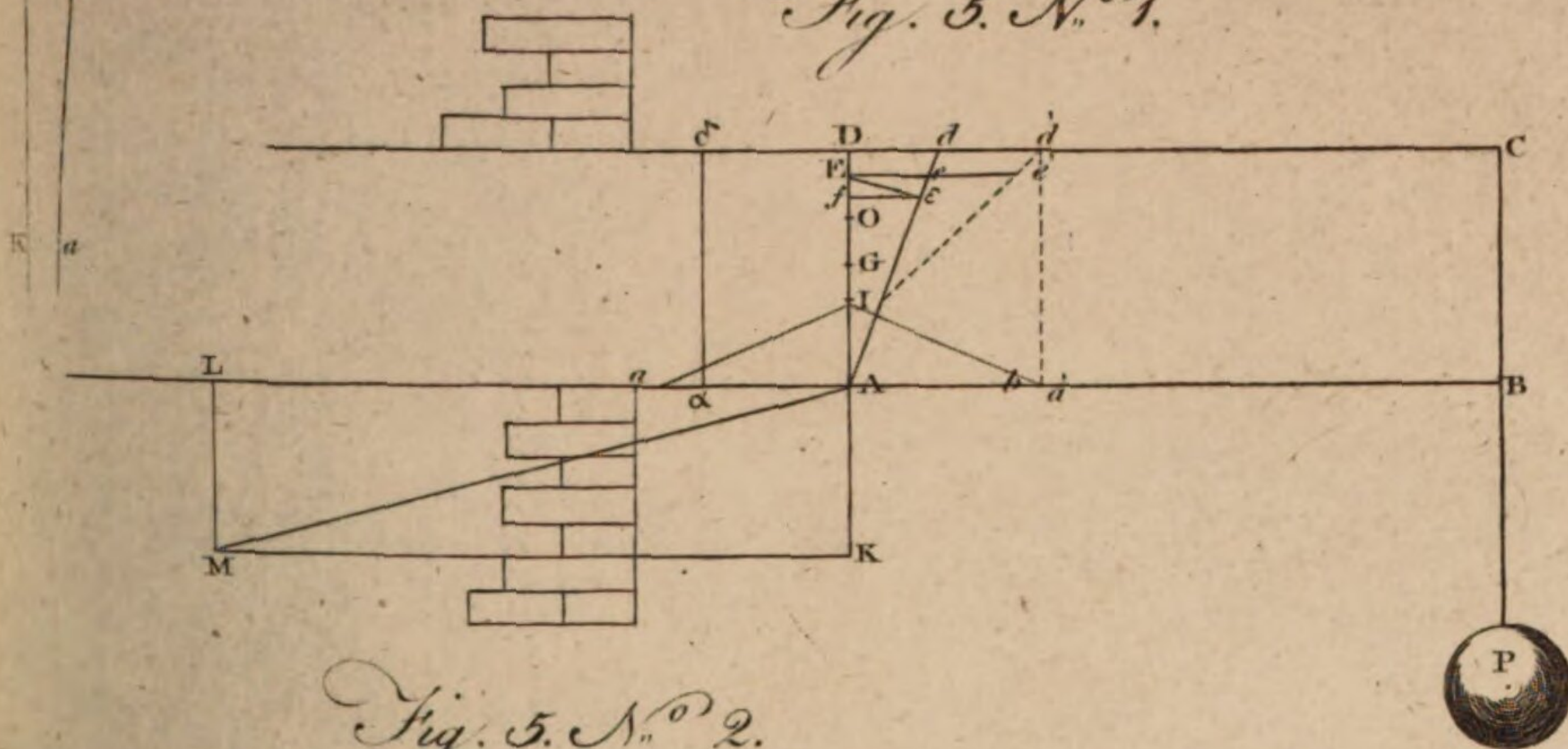


Fig. 5. N^o 2.

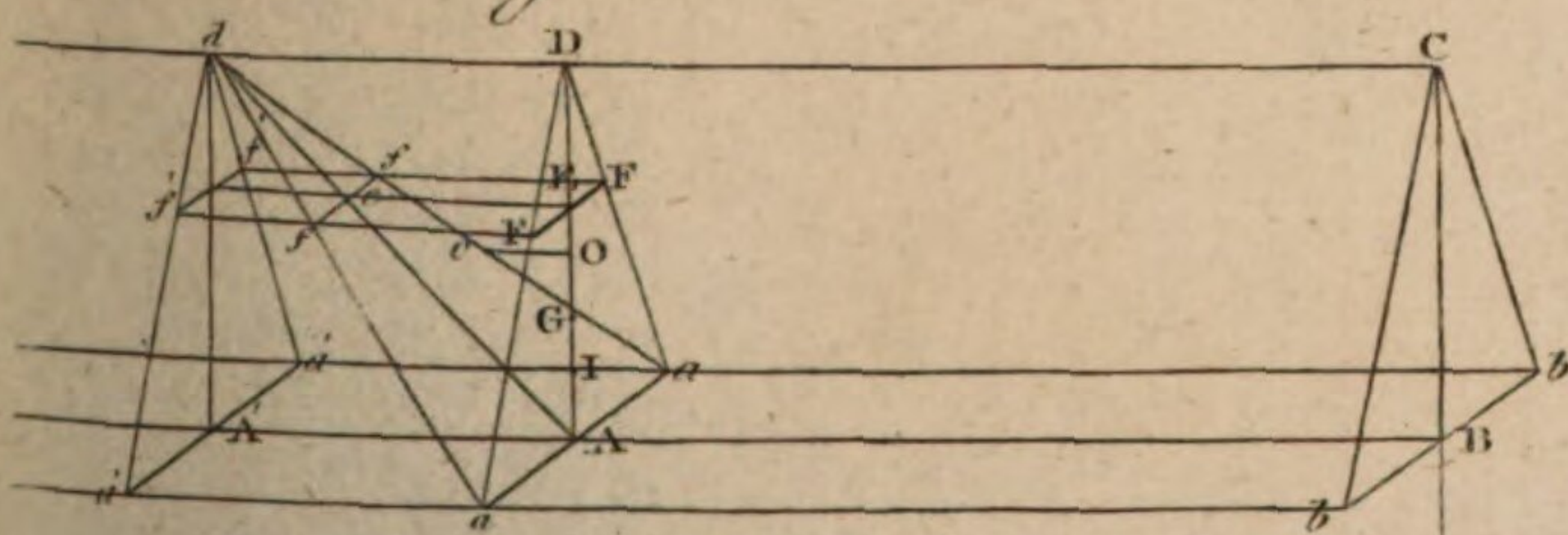


Fig. 5. N^o 3.

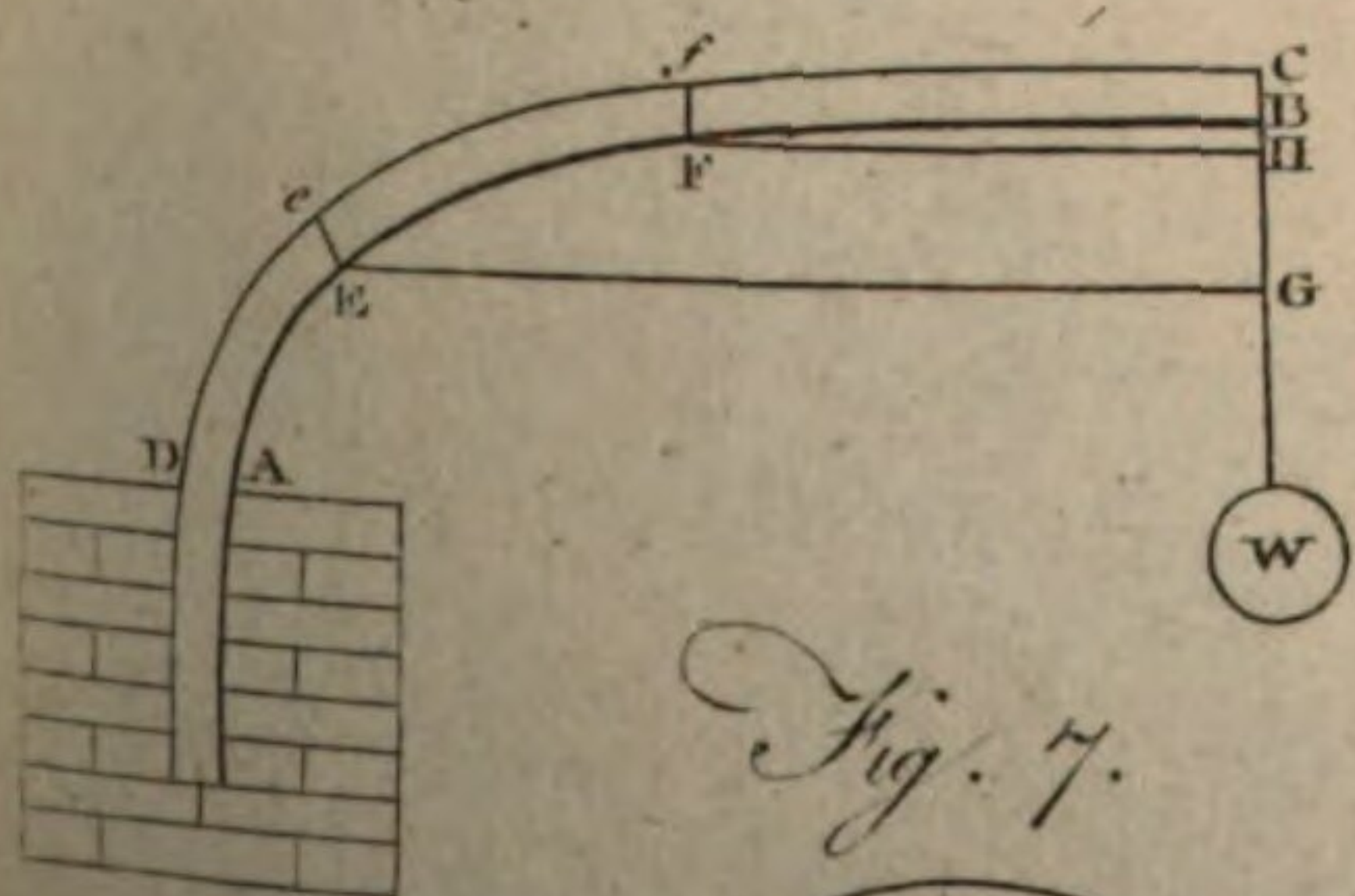


Fig. 7.

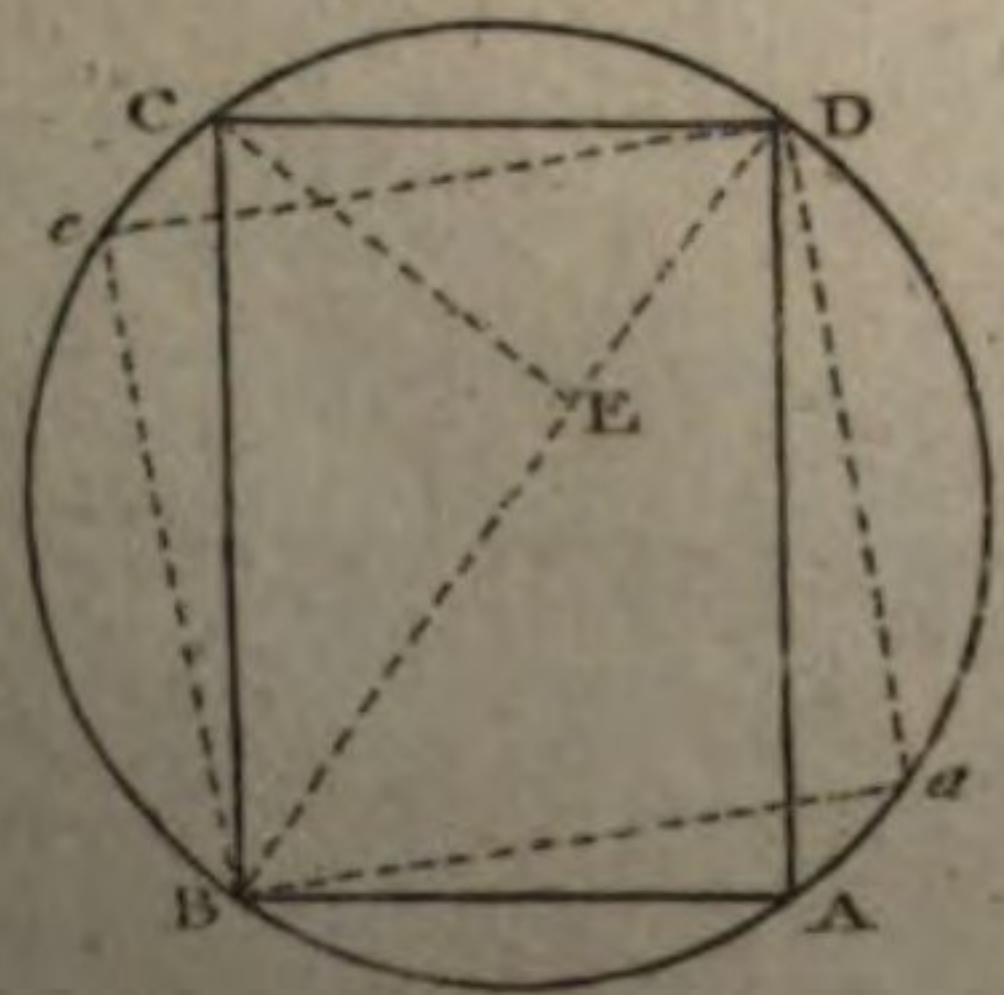


Fig. 8.

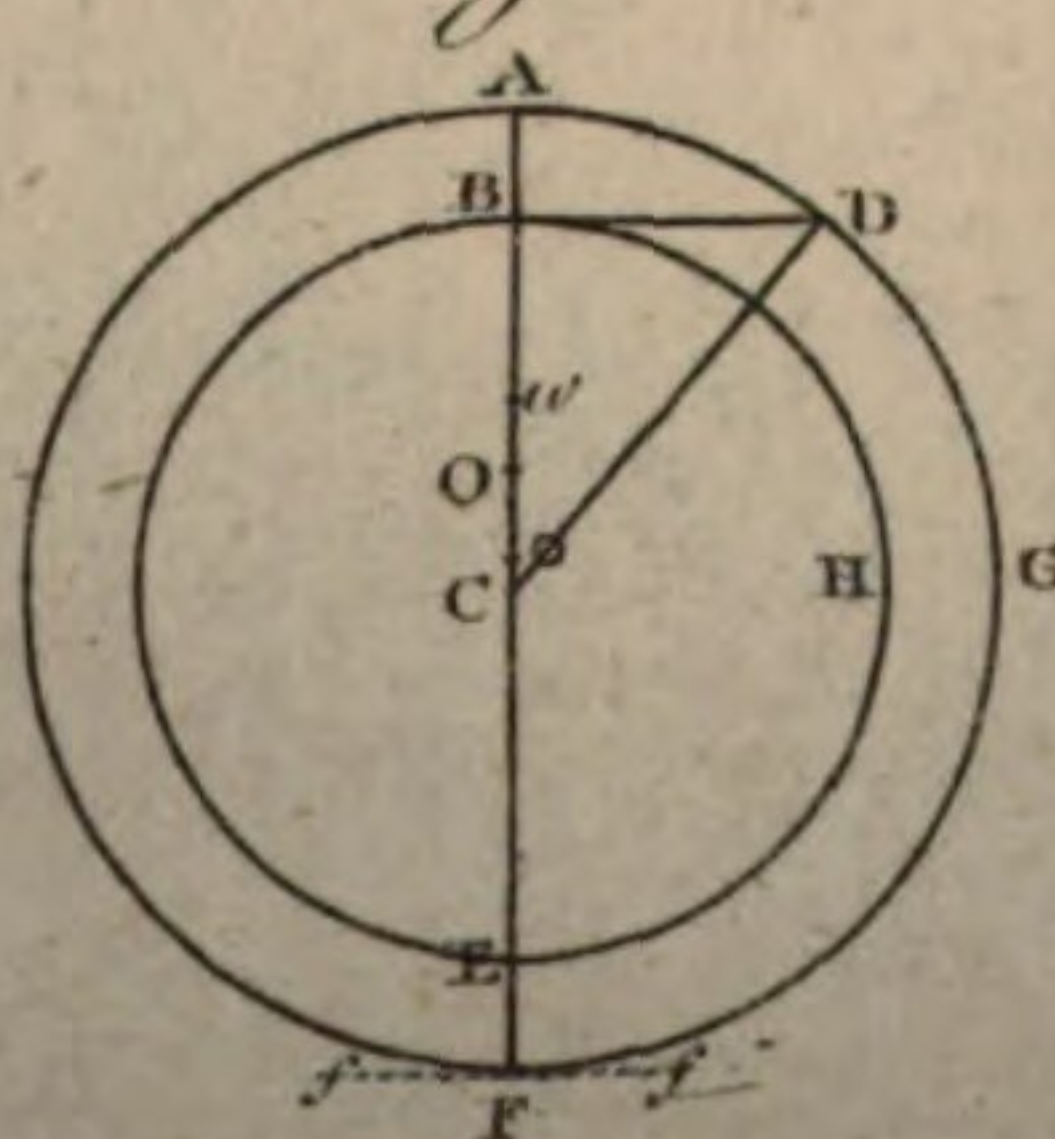


Fig. 3.

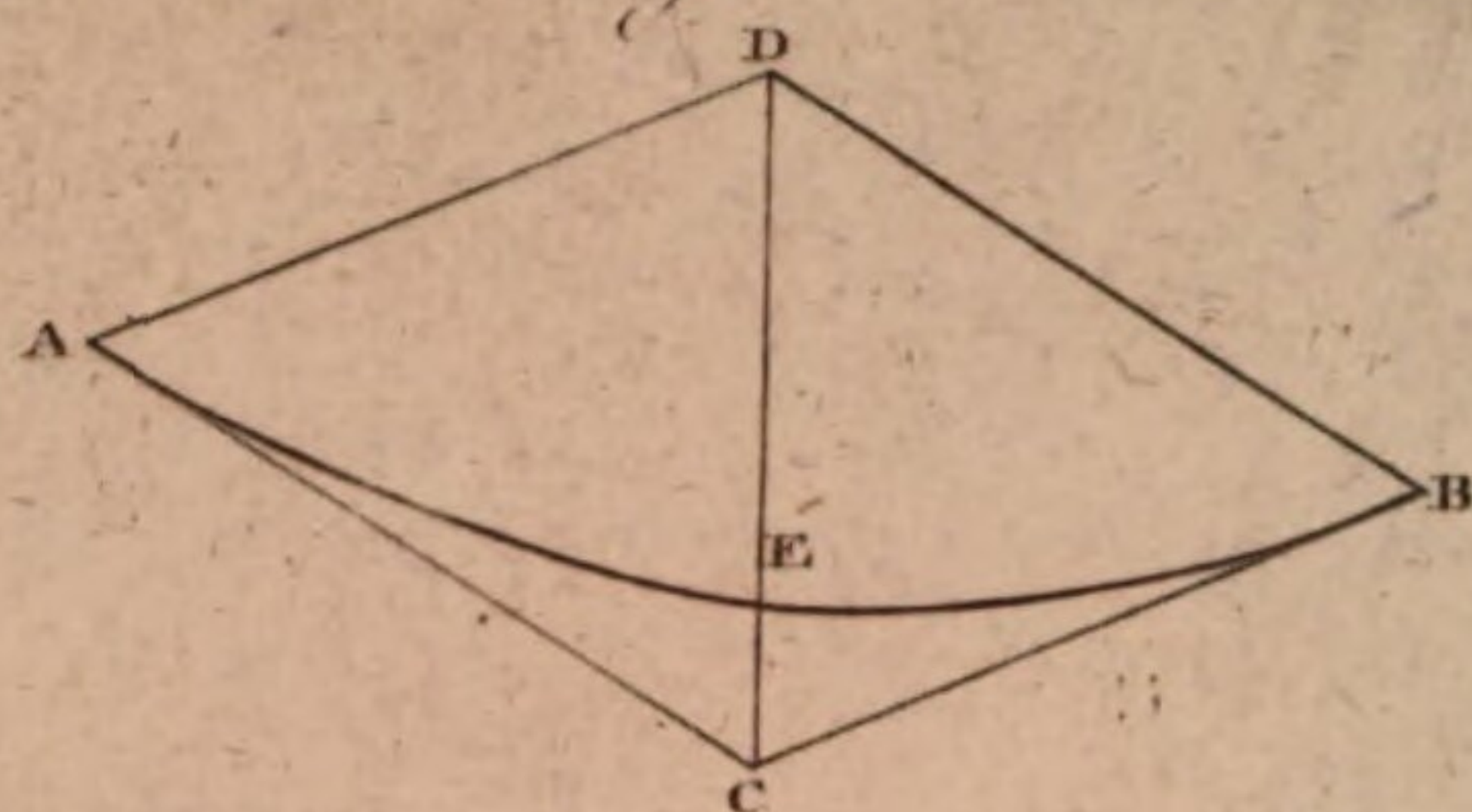


Fig. 4.

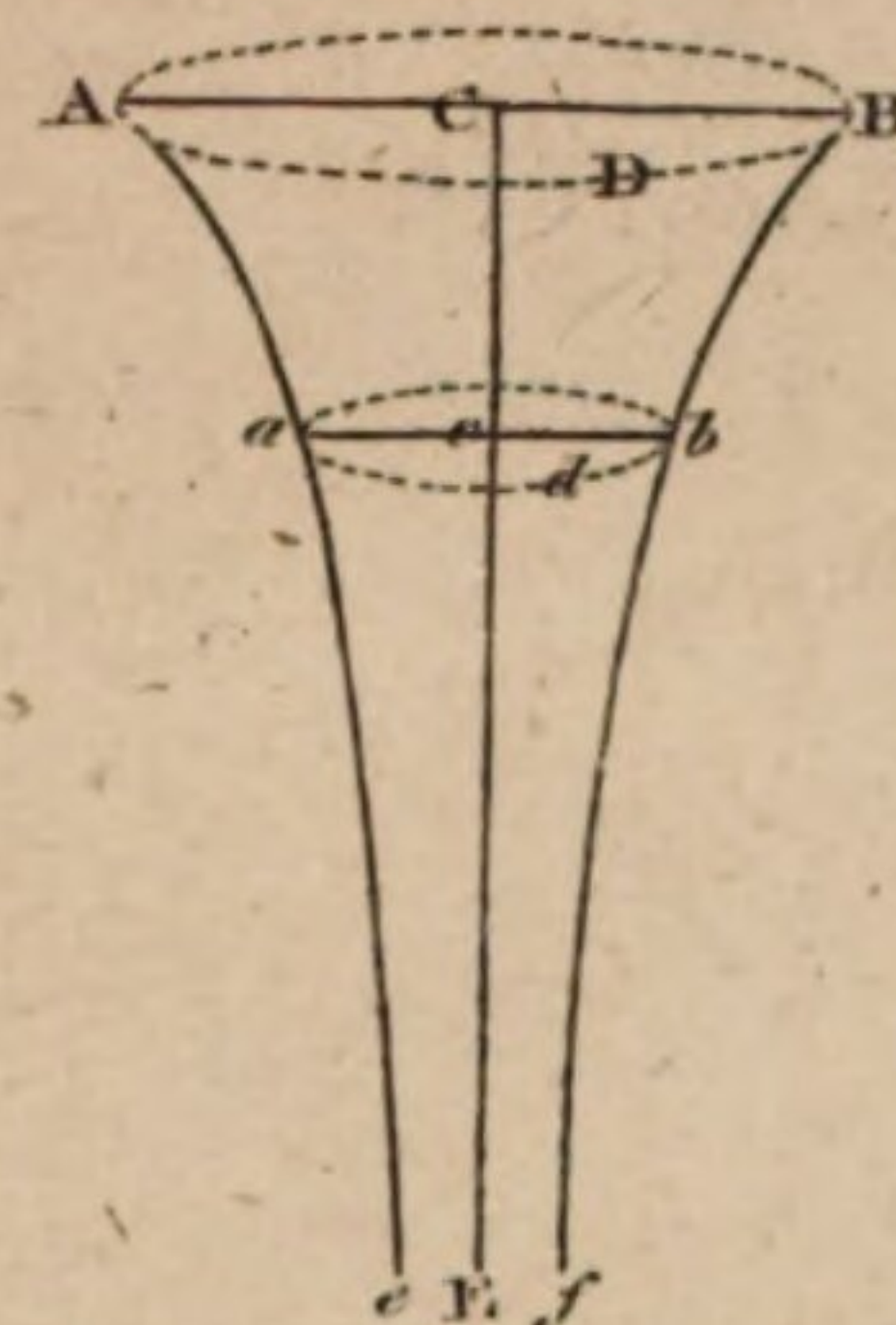


Fig. 6.

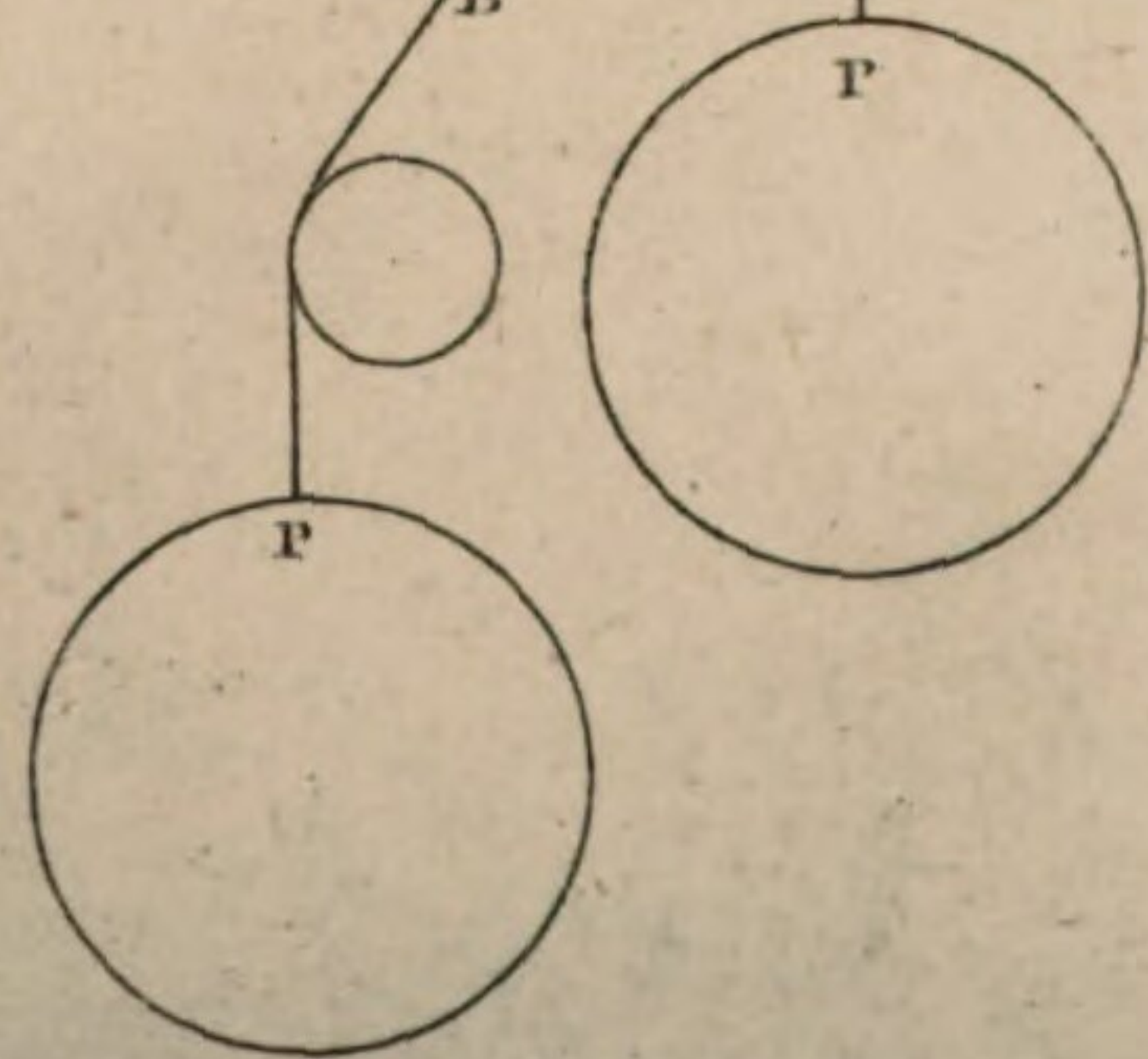
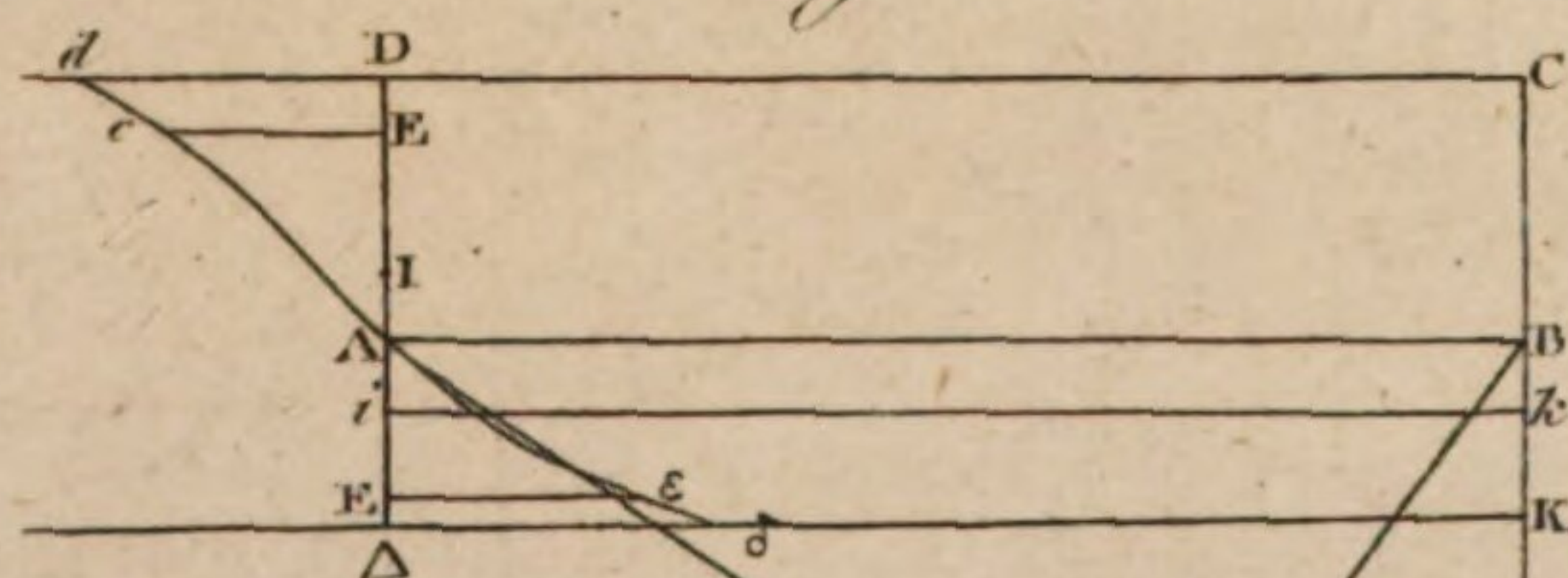


Fig. 9. N^o 1.

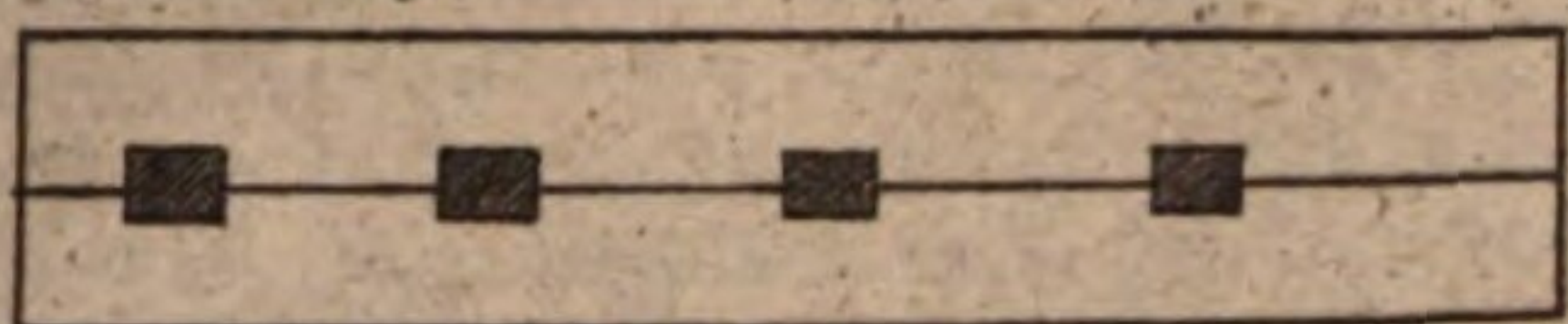


Fig. 10.

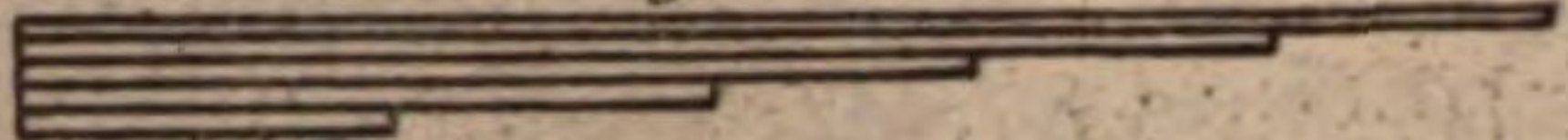


Fig. 13.

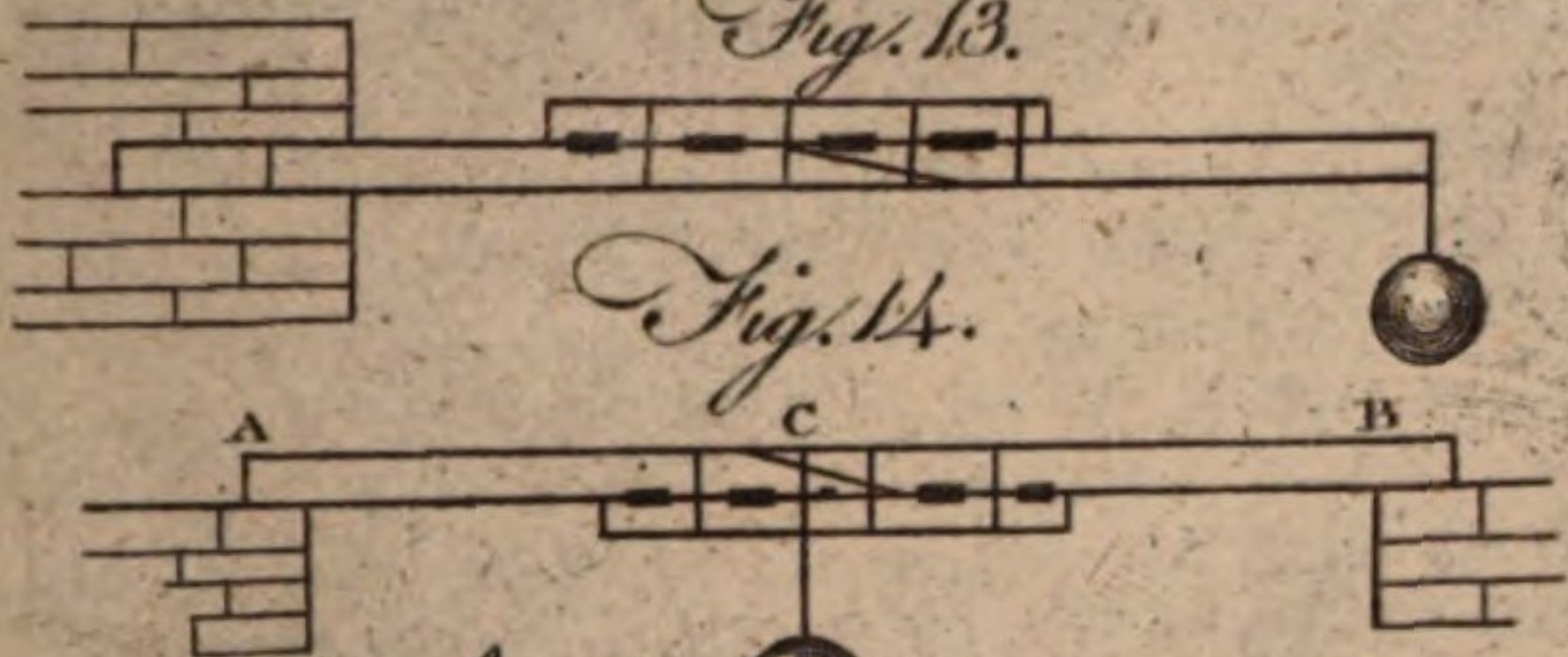


Fig. 14.



Fig. 15.

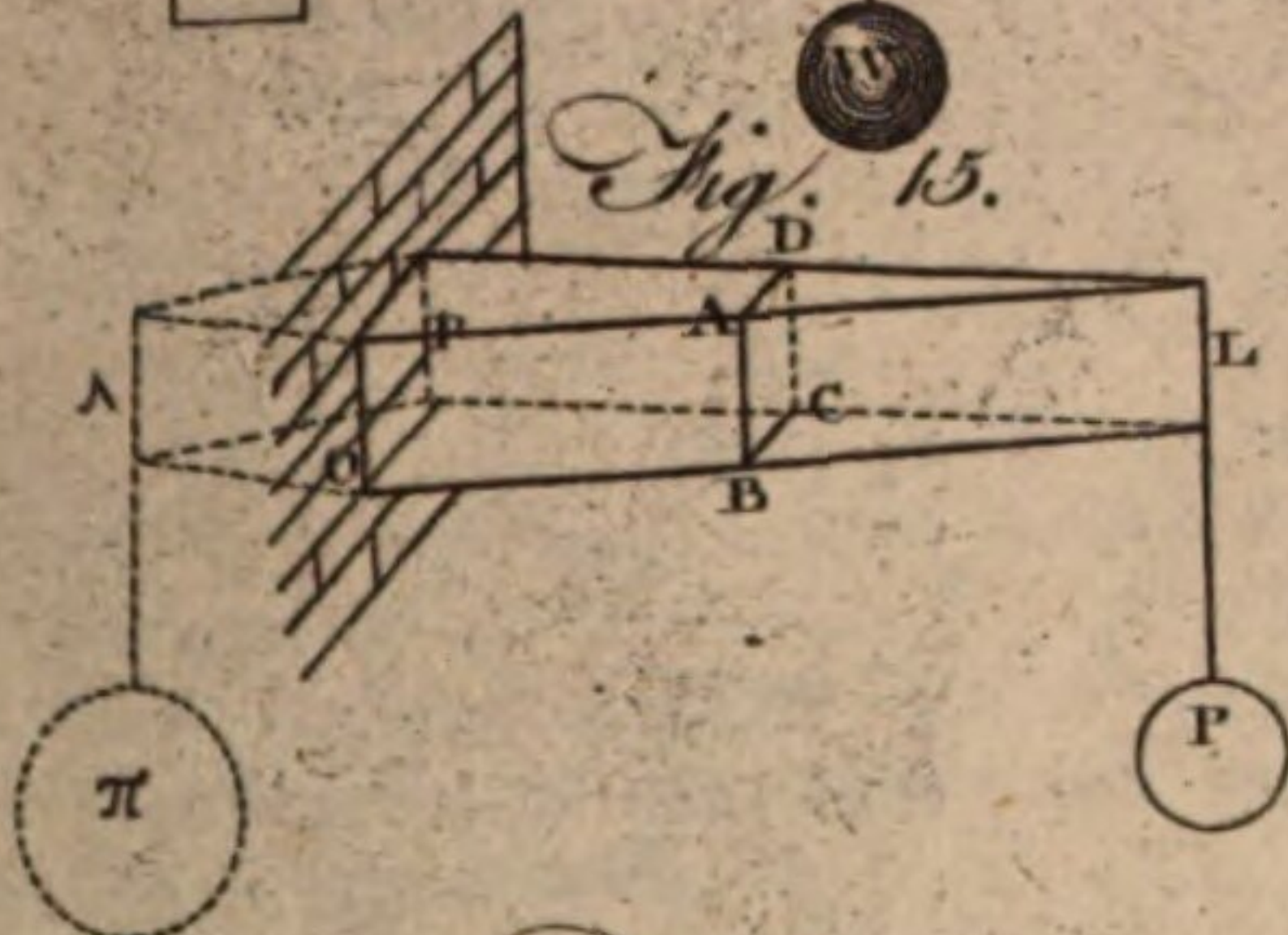


Fig. 17.

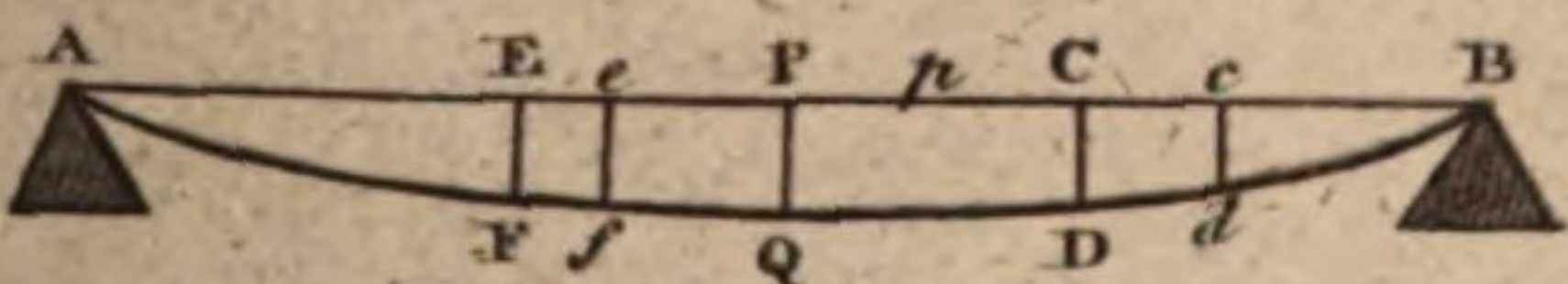


Fig. 18.

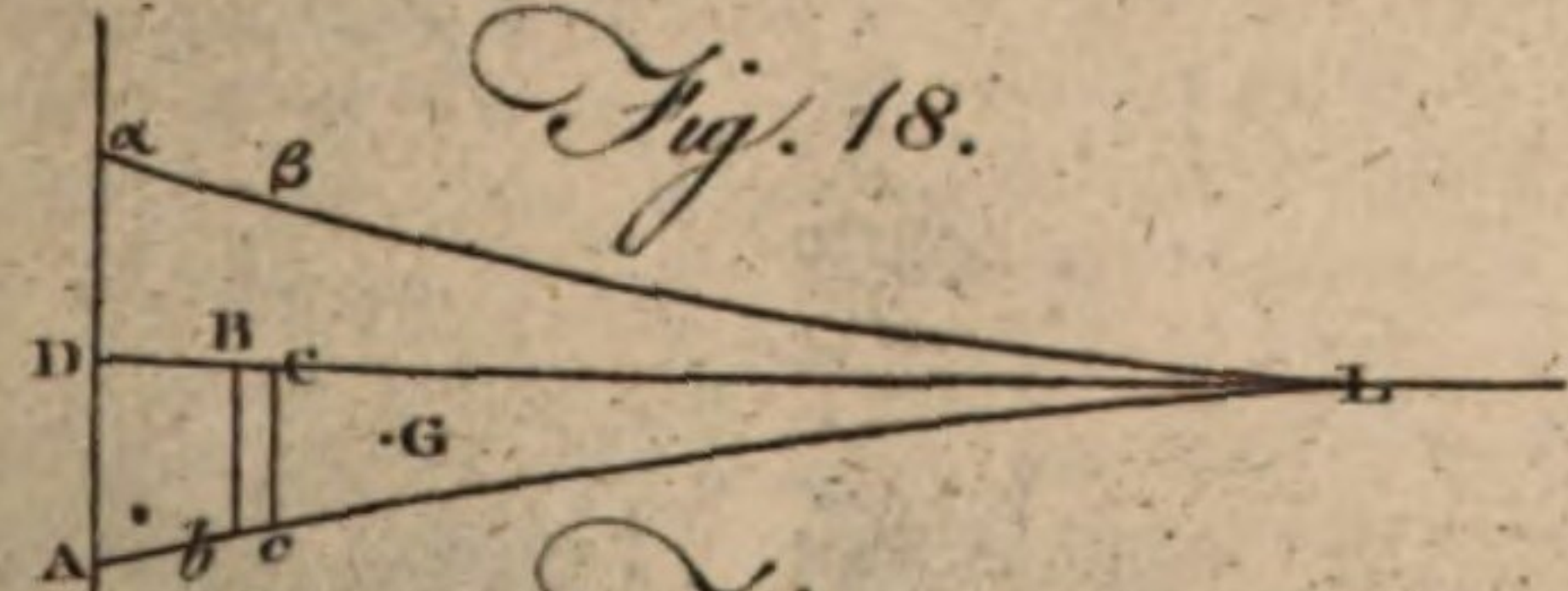


Fig. 19.

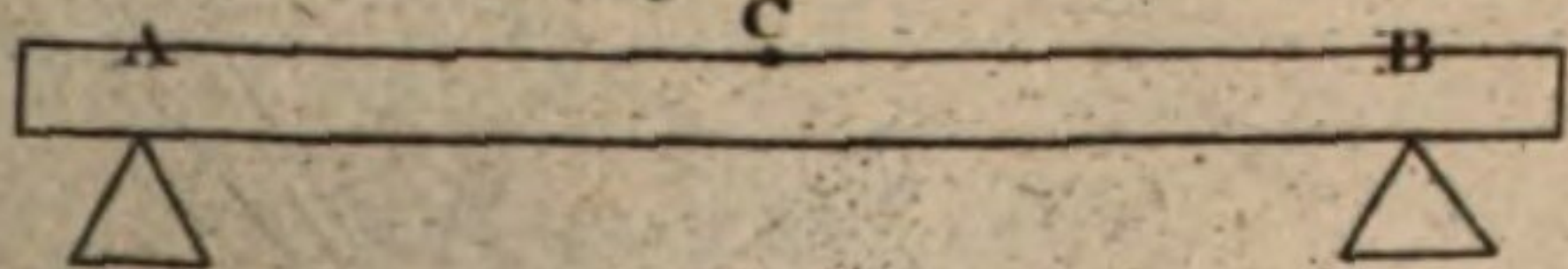


Fig. 22.

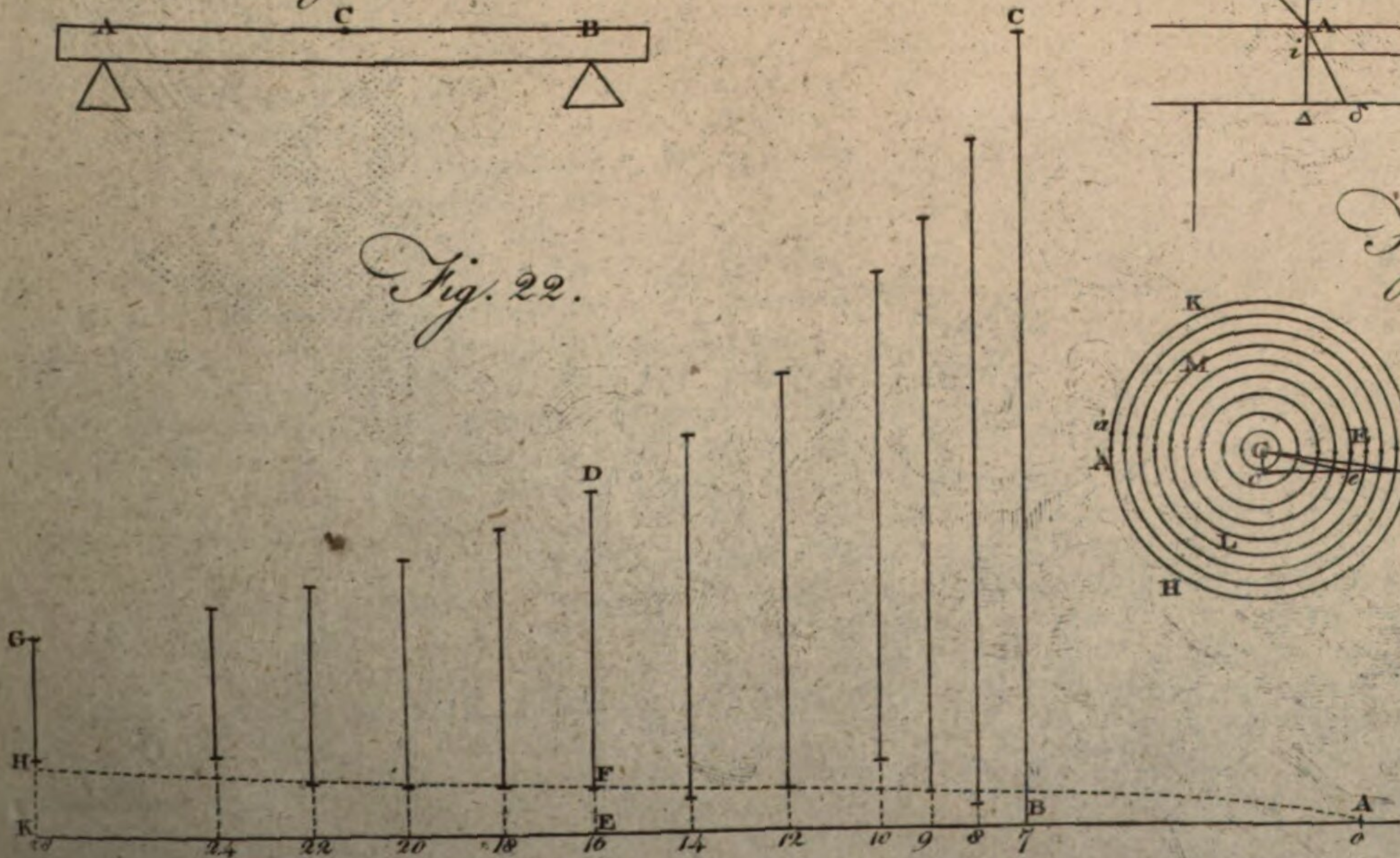


Fig. 9. N^o 2.

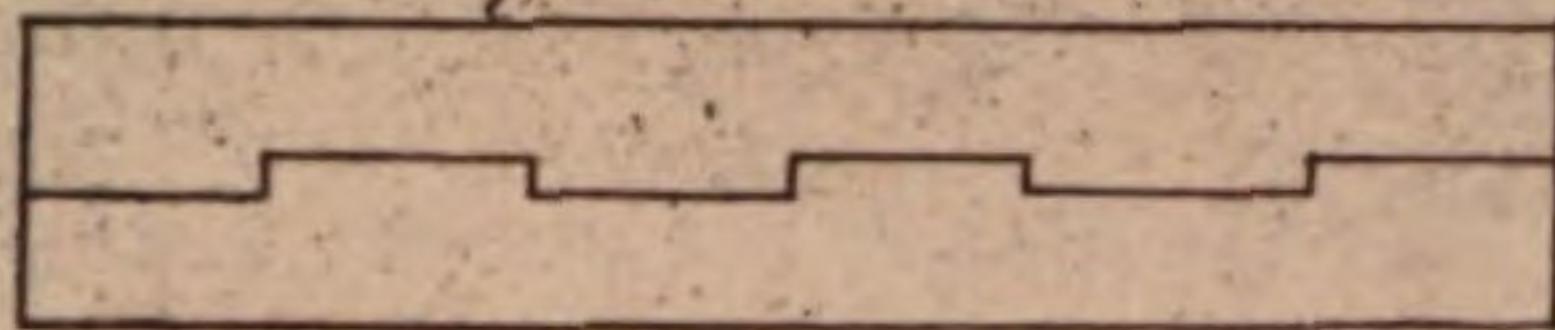


Fig. 11.

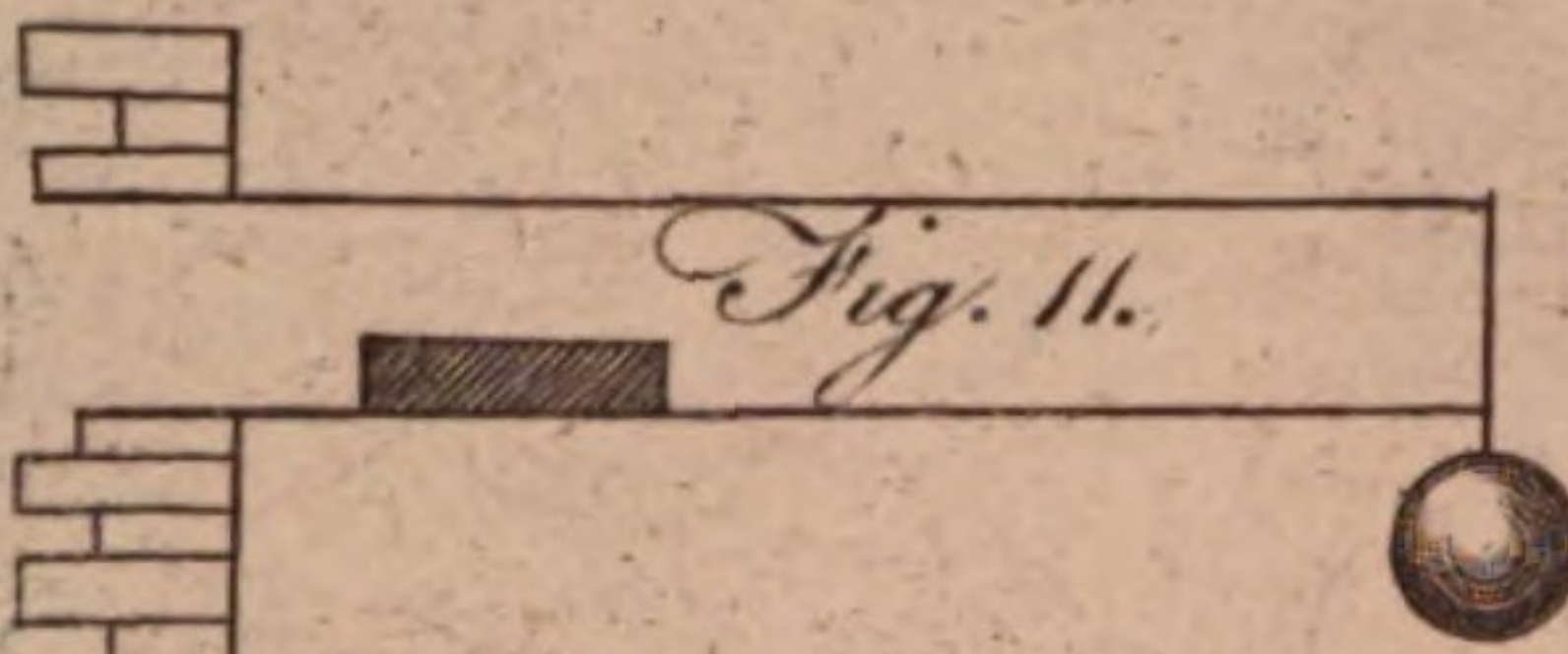


Fig. 12.

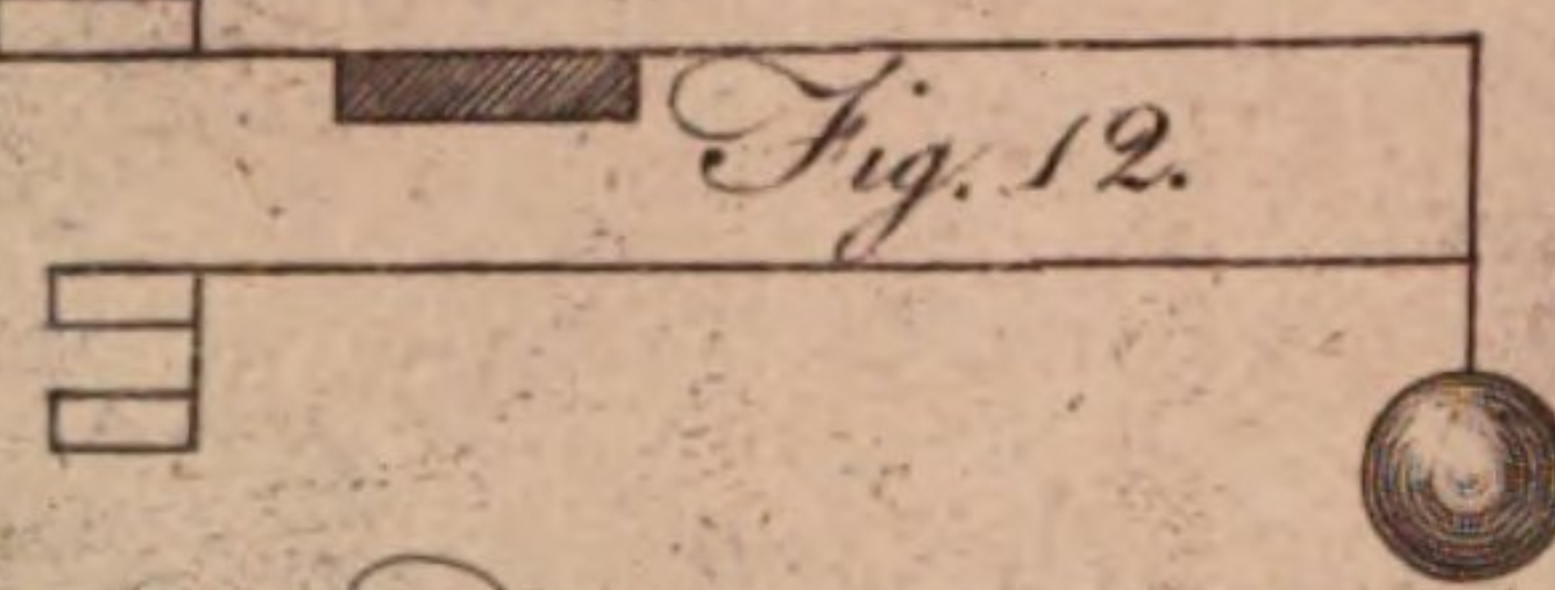


Fig. 16.

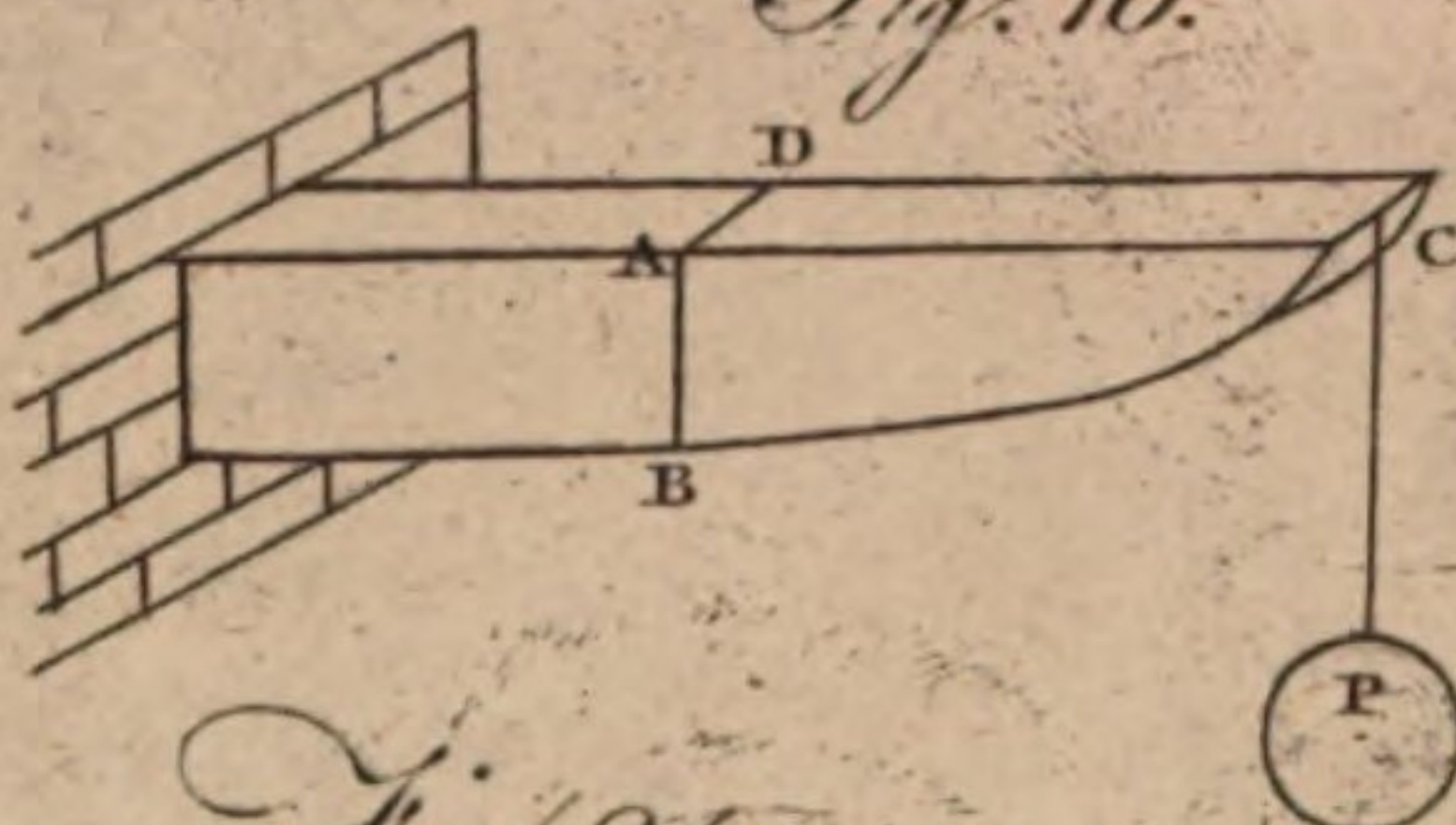


Fig. 21.

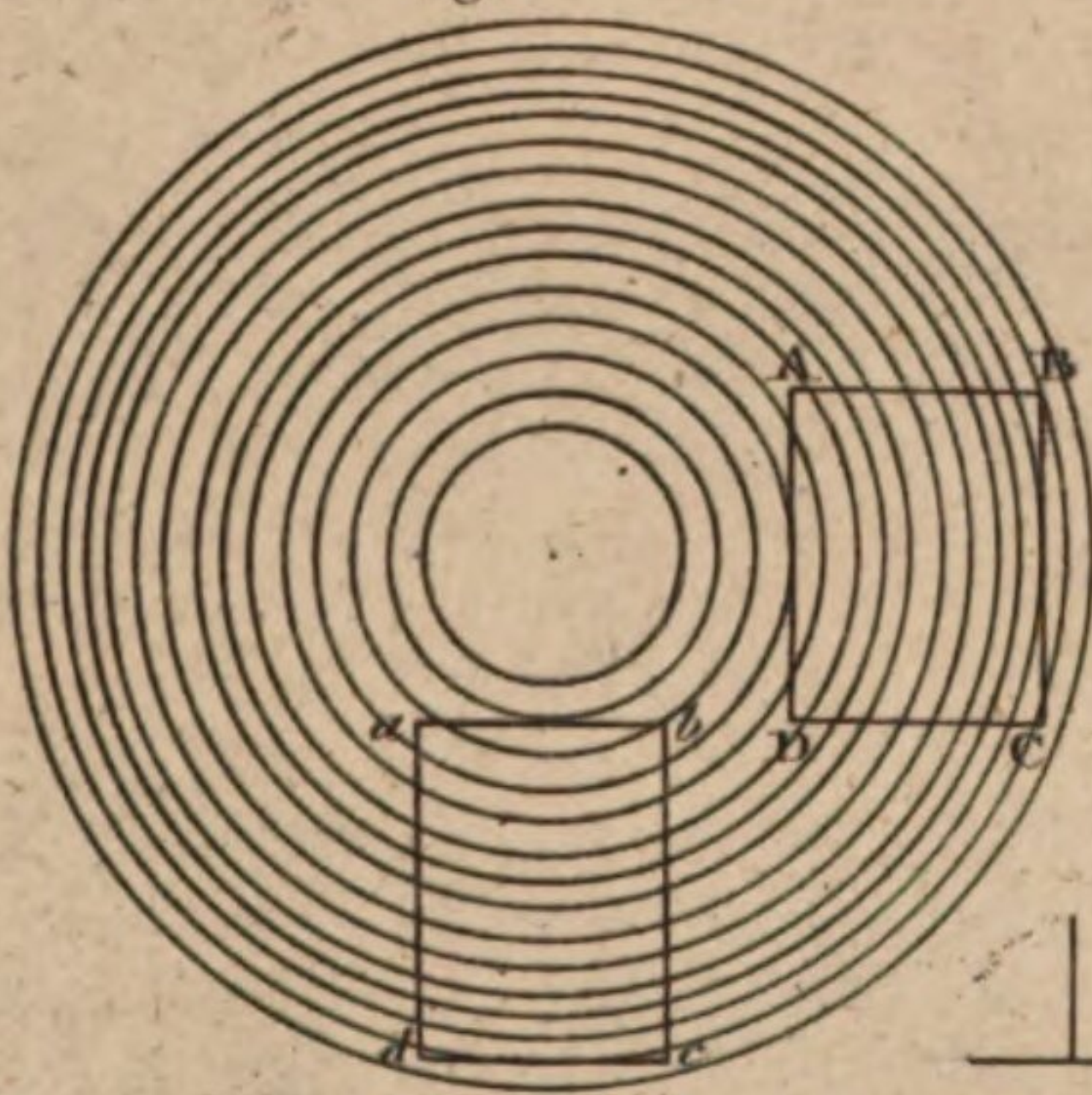


Fig. 20. N^o 1.



Fig. 20. N^o 2.

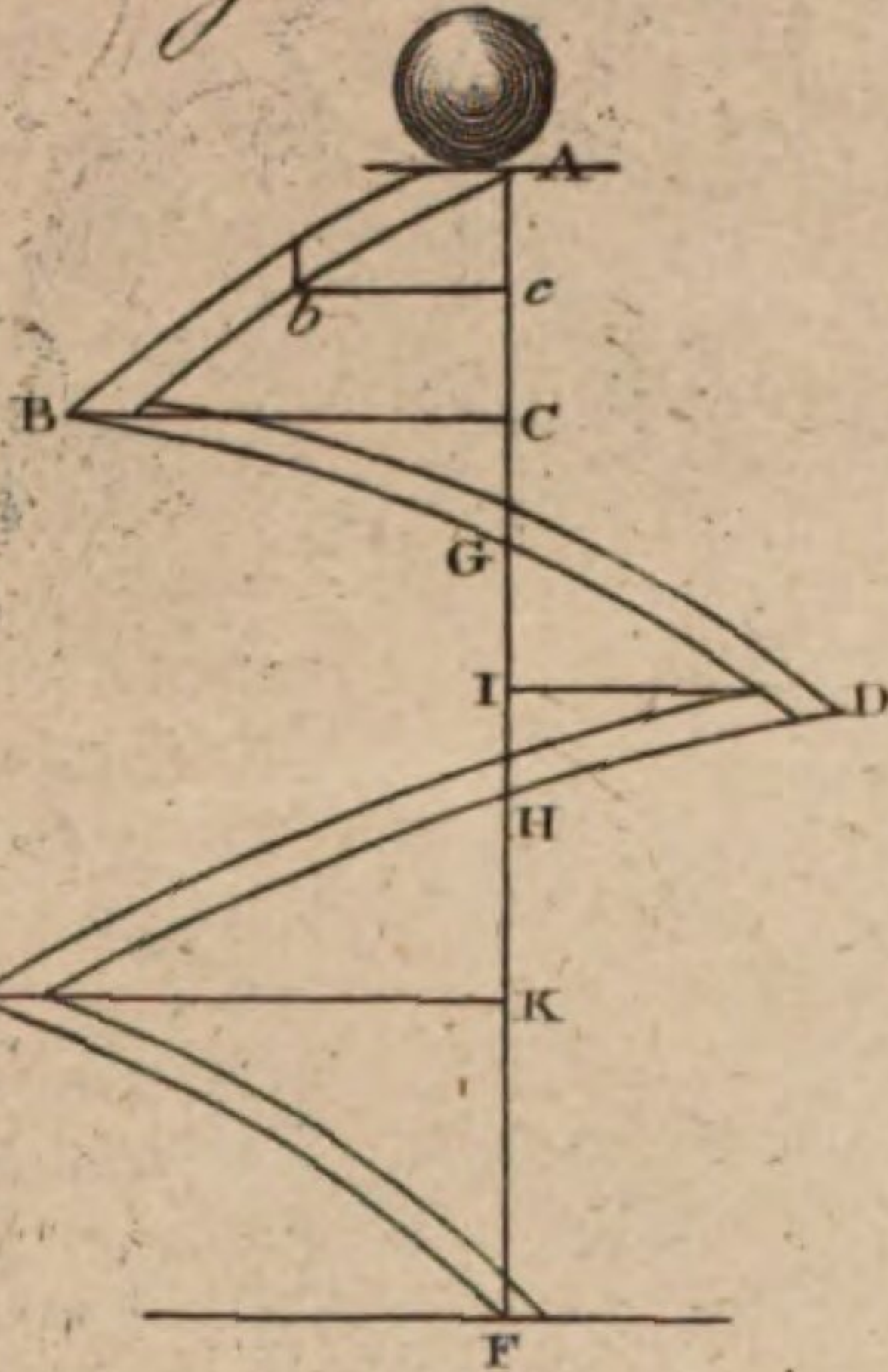


Fig. 23.

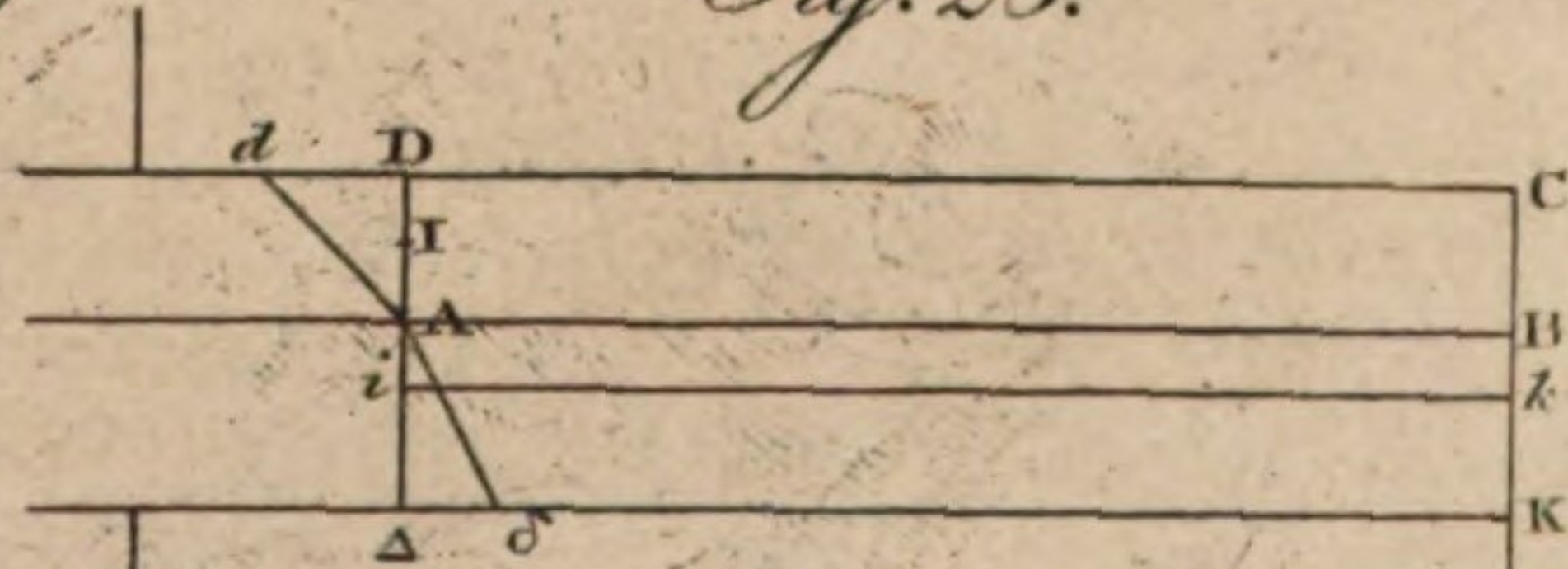


Fig. 25.

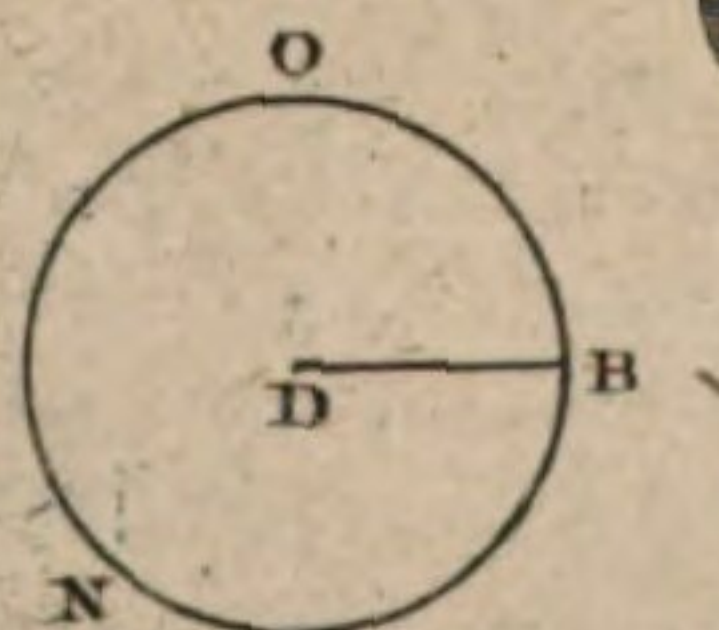
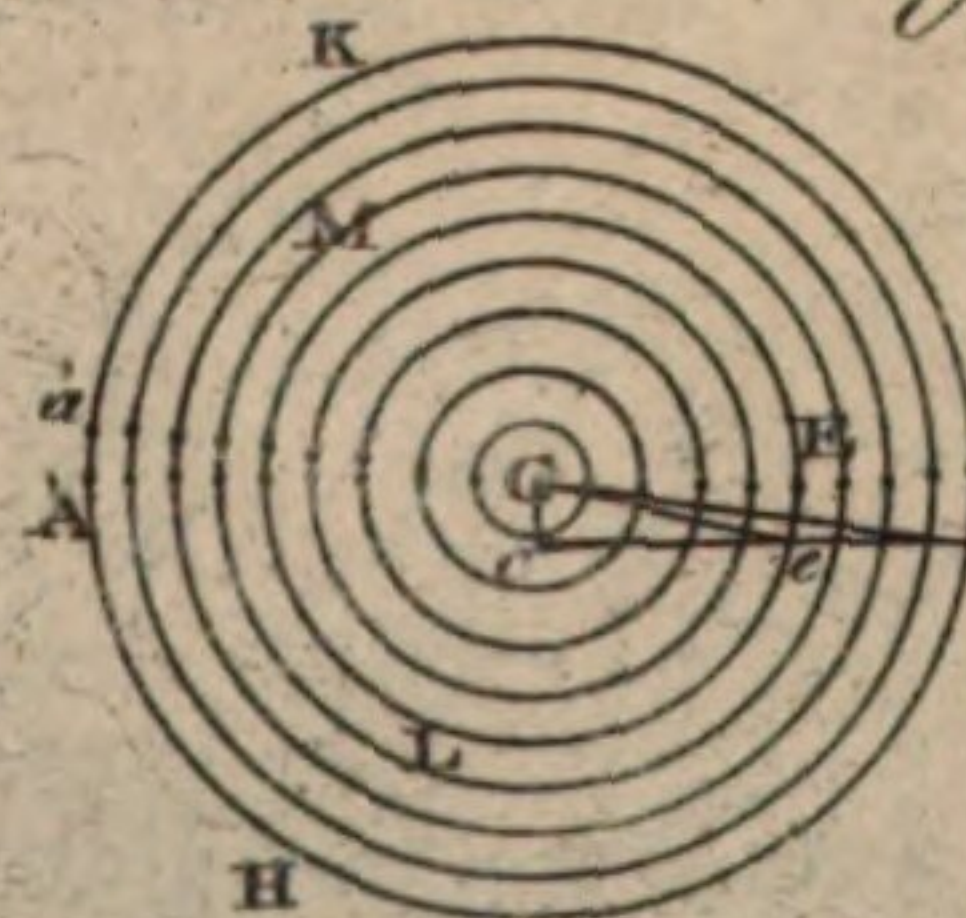
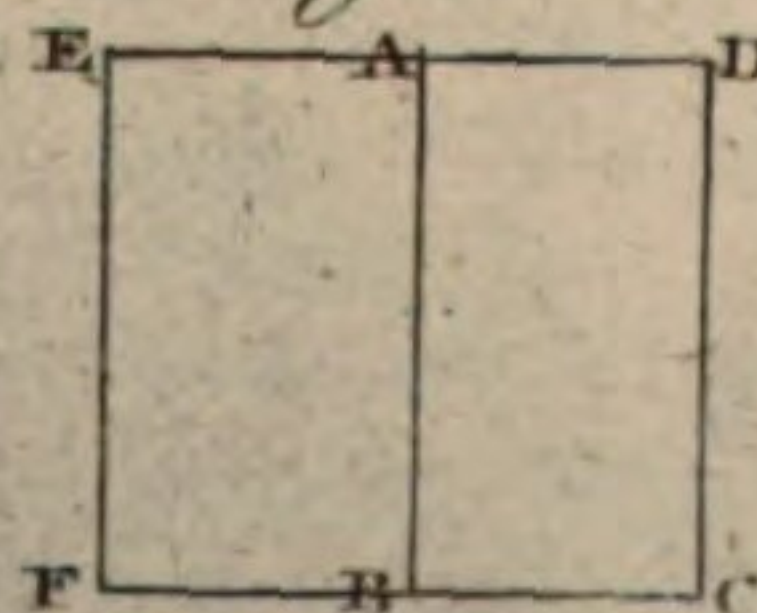


Fig. 24.



Strobilus, of a rufous white: the head and neck are white, and not so full of feathers as those of owls generally are, and from this circumstance it appears not unlike a hawk: a large patch of dark brown surrounds each eye, giving the bird much the appearance of wearing spectacles; the legs are covered with feathers quite to the toes, and are of a yellowish colour. A specimen of this curious bird may be seen in the Leverian museum.

STROBILUS, in botany, a pericarp formed from an amentum by the hardening of the scales,

STROKING, or rubbing gently with the hand, a method which has been employed by some persons for curing diseases.

Mr Greatrakes or Greatrix, the famous Irish stroker, is said to have performed many wonderful cures. He gives the following account of his discovery of this art, and of the success with which he practised it. "About 1662 I had an impulse (says he), or a strange persuasion in my own mind (of which I am not able to give any rational account to another), which did very frequently suggest to me, that there was bestowed on me the gift of curing the king's evil; which, for the extraordinariness of it, I thought fit to conceal for some time; but at length I communicated this to my wife, and told her, that I did verily believe that God had given me the blessing of curing the king's evil; for whether I were in private or public, sleeping or waking, still I had the same impulse. But her reply to me was, that she conceived this was a strange imagination; yet, to prove the contrary, a few days after there was one William Mather of Salterbridge in the parish of Lismore, who brought his son William to my house, desiring my wife to cure him, who was a person ready to afford her charity to her neighbours, according to her small skill in chirurgery. On which my wife told me, there was one that had the king's evil very grievously in the eyes, cheek, and throat; whereupon I told her, that she should now see whether this were a bare fancy or imagination, as she thought it, or the dictates of God's Spirit on my heart. Then I laid my hands on the places affected, and prayed to God for Jesus sake to heal him; and bid the parent two or three days afterwards to bring the child to me again, which accordingly he did; and I then saw the eye was almost quite whole; and the node, which was almost as big as a pullet's egg, was suppurated; and the throat strangely amended; and, to be brief (to God's glory I speak it) within a month discharged itself quite, and was perfectly healed, and so continues, God be praised."

Then there came to him one Margaret Macshane of Bal-linelly, in the parish of Lismore, who had been afflicted with the evil above seven years, in a much more violent degree; and soon after, his fame increasing, he cured the same disease in many other persons for three years. He did not meddle all this time with any other distemper; till about the end of these three years, the ague growing epidemical, he found, as formerly, that there was bestowed on him the gift of curing that disease. He cured Colonel Phaire, of Cahirmony in the county of Corke, of an ague, and afterwards many other persons of different distempers, by stroking; so that his name was wonderfully cried up, as if some divine person had been sent from above. January 1665-6, he came over to England, at the request of the earl of Or-rery; in order to cure the lady of the lord-viscount Conway, of Ragley in Warwickshire, who had for many years laboured under a most violent headache. He staid at Ragley three weeks or a month; and though he failed in his endeavours to relieve that lady, he cured vast numbers of people in those parts and at Worcester.

Though we are no friends to the marvellous, nor believe

it possible that either the king's evil or ague can be cured by Stroking or friction of any kind, whether gentle or severe, we have no hesitation to acknowledge that many cures might be performed by Mr Greatrakes. Every reflecting person who reads the foregoing account which he gives of himself will see that he was an enthusiast, and believed himself guided by a particular revelation; and such is the credulity of mankind, that his pretensions were readily admitted, and men crowded with eagerness to be relieved of their diseases. But it is well known to physicians, that in many cases the imagination has accomplished cures as wonderful as the force of medicine. It is owing chiefly to the influence of imagination that we have so many accounts from people of veracity of the wonderful effects of quack medicines. We are perfectly assured that these medicines, by their natural operation, can never produce the effects ascribed to them; for there is no kind of proportion between the medicine and the effect produced, and often no connection between the medicine and the disease.

STROMATEUS, in ichthyology, a genus of fishes belonging to the order of *apodes*. The head is compressed; the teeth are placed in the jaws and palate; the body is oval and slippery; and the tail is forked. There are three species according to Gmelin, the fiatola, paru, and cumarca.

STROMBOLI, the most northern of the Lipari islands. It is a volcano, which constantly discharges much fire and smoke. It rises in a conical form above the surface of the sea. On the east side it has three or four little craters ranged near each other, not at the summit, but on the declivity, nearly at two-thirds of its height. But as the surface of the volcano is very rugged, and intersected with hollow ways, it may be naturally concluded, that at the time of some great eruption, the summit and a part of this side fell in, as must have happened also to Vesuvius; consequently, the common chimney is at this day on the declivity, although always in the centre of the whole base. It is inhabited notwithstanding its fires; but care is taken to avoid the proximity of the crater, which is yet much to be feared. "I was assured (says M. de Luc) by an Englishman, who, like me, had the curiosity to visit these isles, that the fine weather having invited him and his company to land at Stromboli, they ascended a volcano, whose craters at that time threw out nothing; but that while they were attentively viewing them, unapprehensive of any danger, they were suddenly saluted by such a furious discharge, as to be obliged to retreat with precipitation, and not without one of the company being wounded by a piece of scoria." Of all the volcanoes recorded in history, Stromboli seems to be the only one that burns without ceasing. Etna and Vesuvius often lie quiet for many months, and even years, without the least appearance of fire; but Stromboli is ever at work, and for ages past has been looked upon as the great lighthouse of these seas. E. Long. 15.45. N. Lat. 30.0.

STROMBUS, in natural history, a genus of *vermes*, belonging to the order of *testacea*. The animal is a limax; the shell is univalve and spiral; the opening is much dilated, and ends in a canal which turns to the left. Gmelin enumerates 53 species; of which only one is peculiar to Britain, the *pes pelecani*. The spires are ten; the lip is fingered; the point very sharp; the length two inches.

STRONGOLI, a town of the kingdom of Naples, with a bishop's see. It is situated on a rugged mountain, is about three miles from the sea, and seven north from St Severino. It is supposed to be the ancient *Petelia*, which made a conspicuous figure in the second Punic war by its obstinate resistance against Hannibal. Near its walls Marcellus the ri-

Strontites. val of Hannibal was slain in a skirmish. E. Long. 17. 26.
N. Lat. 39. 20.

STRONTITES, or STRONTIAN EARTH, a new species of earth lately discovered at Strontian in Scotland.

Who the discoverer of this earth was we have not learned; but Dr Kirwan says, the first information he received of it was from Dr Crawford in the year 1790. In the *Miners Journal* for February 1791 a good description of its external appearance, with some account of its chemical properties, was published from the observations of Mr Sulzer. Dr Kirwan examined it in October 1793, and found it to be a new earth between the barytic and common limestone. Dr Hope, who is now joint professor of chemistry with Dr Black in the university of Edinburgh, read a paper on the 4th November 1793 before the Royal Society of Edinburgh, intitled "An Account of a Mineral from Strontian, and of a peculiar Species of Earth which it contains;" an abridgment of which is published in the third volume of the *Edinburgh Philosophical Transactions*. Mr Schmeisser read a paper on the same subject before the Royal Society of London in May 1794, which is published in their *Transactions* for that year, p. 418, &c.

*Transactions of the
Irish Academy, vol.
v.*

Its external characters are these: Its colour is whitish or light green; its lustre common; its transparency intermediate between the semitransparent and opaque; its fracture striated, presenting oblong distinct concretions, somewhat uneven and bent; its hardness moderate, being easily scratched, but not scraped. It is very brittle; and its specific gravity from 3,4 to 3,644.

For a full account of its chemical qualities we must refer to the books already mentioned, as all the accounts of it which we have seen are too long to insert here, and as we do not consider the circumstance of its being a newly discovered earth a sufficient reason for running into a tedious detail till its utility be ascertained. We shall, however, mention some of its most remarkable qualities. It requires 180 times its weight of water at a low temperature to dissolve it. When dissolved in boiling water, and allowed to cool, it deposits transparent crystals, which when exposed to the air become white and powdery. It is not affected by the sulphuric acid; but when diluted, 10,000 parts of it will dissolve one of strontites. Diluted nitric acid dissolves it rapidly. The muriatic acid, whether diluted or oxygenated, dissolves it in a similar manner.

*Transactions of the
Royal Society of Edinburgh, vol.
iii.*

Strontites has a strong resemblance to barytes, but essentially differs from it. Its specific gravity is less; it parts with its carbonic acid when urged by heat somewhat more readily, and without suffering fusion; when calcined, it imbibes moisture with vastly greater avidity, swelling and cracking with more heat and noise. Strontites dissolves much more abundantly in hot water than barytes; and the form of the crystals of these pure earths is very dissimilar. The compounds generated by strontites differ from those of barytes. It will suffice to mention the nitrate and muriate. This earth, united to nitric and muriatic acid, forms salts that suffer changes from exposure to air, which do not happen to the nitrate and muriate of barytes. They are likewise much more soluble in water, and have crystals of a peculiar figure. The combinations of strontites with acids are not, like those of barytes, decomposed by prussiate of lime or of potash. Strontites and its compounds tinge flame, which barytes does not. Lastly, these earths disagree in the order of their attractions. From these considerations it is concluded, that the mineral is not aerated barytes.

It also is distinguished from calcareous spar or limestone: for it is much heavier, and retains its fixed air with more obstinacy in the fire. The incomparably greater solubility

of the pure earth in hot than in cold water, and the crystalline form it assumes, sufficiently distinguish it from lime, which the disposition of the nitrate and muriate to crystallize no less tends to do.

The most remarkable quality of strontites is that of tinging flame of a red colour. The muriate has it in the most eminent degree, and its effects are well exhibited by putting a portion of the salt on the wick of a candle, which is thereby made to burn with a very beautiful blood-red flame. The nitrate stands next, then crystallized strontites, and after it the acetite. A hundred parts of strontites are composed of 61.21 of earth, 30.20 of carbonic acid, and 8.59 of water.

STROPHE, in ancient poetry, a certain number of verses, including a perfect sense, and making the first part of an ode. See POETRY, n° 130.

STRUMÆ, scrophulous tumors arising on the neck and throat, constituting what is commonly called the *king's evil*. See MEDICINE, n° 349.

STRUMPFIA, in botany; a genus of plants belonging to the class of *syngenesia*, and to the order of *monogamia*. The calyx is quinque-dentate and superior; the corolla is pentapetalous; and the berry monospermous. There is only one species, the *maritima*.

STRUTHIO, in natural history; a genus of birds belonging to the order of *grallæ* of Linnæus; but, according to the new classification of Dr Latham, it forms, along with the dodo, cassuarius, and rhea, a separate order under the name of *struthious*. As the dodo or didus, and rhea, have been already described in their proper place, we will now give some account of the ostrich and cassowary.

I. The OSTRICH (the *Camelus* of Linnæus) has a bill somewhat conical; the wings are so short as to be unfit for flying; the thighs and sides of the body are naked; the feet are formed for running, having two toes, one only of which is furnished with a nail. In this respect it differs entirely from the cassowary, which has three toes complete. The ostrich is without doubt the largest of all birds: it is nearly eight feet in length, and when standing upright from six to eight feet in height. We are told in the *Gentleman's Magazine**, that two ostriches were shown in London in the year 1750, and that the male was 10 feet in height, and weighed three hundred weight and a quarter. The head and bill somewhat resemble those of a duck; and the neck may be likened to that of a swan, but that it is much longer; the legs and thighs resemble those of an hen; though the whole appearance bears a strong resemblance to that of a camel. But though usually seven feet high from the top of the head to the ground, from the back it is only four; so that the head and neck are above three feet long. From the top of the head to the rump, when the neck is stretched out in a right line, it is six feet long, and the tail is about a foot more. One of the wings, without the feathers, is a foot and an half; and being stretched out, with the feathers, is three feet.

The plumage is much alike in all; that is, generally black and white; though some of them are said to be grey. There are no feathers on the sides, nor yet on the thighs, nor under the wings. The lower part of the neck, about half way, is covered with still smaller feathers than those on the belly and back; and those also are of different colours.

All these feathers are of the same kind, and peculiar to the ostrich; for other birds have several sorts, some of which are soft and downy, and others hard and strong. Ostrich-feathers are almost all as soft as down, being utterly unfit to serve the animal for flying, and still less adapted to be a proper defence against external injury. The feathers

Strophe
Struthio.

Plate
ccccclxxvi.

* Vol. xx.
p. 536.

Struthio. of other birds have the webs broader on one side than the other, but those of the ostrich have their shaft exactly in the middle. The upper part of the head and neck are covered with a very fine clear white hair, that shines like the bristles of a hog; and in some places there are small tufts of it, consisting of about 12 hairs, which grow from a single shaft about the thickness of a pin.

At the end of each wing there is a kind of spur almost like the quill of a porcupine. It is an inch long, being hollow and of an horny substance. There are two of these on each wing; the largest of which is at the extremity of the bone of the wing, and the other a foot lower. The neck seems to be more slender in proportion to that of other birds, from its not being furnished with feathers. The skin in this part is of a livid flesh-colour, which some, improperly, would have to be blue. The bill is short and pointed, and two inches and an half at the beginning. The external form of the eye is like that of a man, the upper eye-lid being adorned with eye-lashes which are longer than those on the lid below. The tongue is small, very short, and composed of cartilages, ligaments, and membranes, intermixed with fleshy fibres. In some it is about an inch long, and very thick at the bottom; in others it is but half an inch, being a little forked at the end.

The thighs are very fleshy and large, being covered with a white skin inclining to redness, and wrinkled in the manner of a net, whose meshes will admit the end of the finger. Some have very small feathers here and there on the thighs; and others again have neither feathers nor wrinkles. What are called the legs of birds, in this are covered before with large scales. The end of the foot is cloven, and has two very large toes, which, like the leg, are covered with scales. These toes are of unequal sizes. The largest, which is on the inside, is seven inches long, including the claw, which is near three-fourths of an inch in length, and almost as broad. The other toe is but four inches long, and is without a claw.

The internal parts of this animal are formed with no less surprising peculiarity. At the top of the breast, under the skin, the fat is two inches thick; and on the fore-part of the belly it is as hard as suet, and about two inches and an half thick in some places. It has two distinct stomachs. The first, which is lowermost, in its natural situation somewhat resembles the crop in other birds; but it is considerably larger than the other stomach, and is furnished with strong muscular fibres, as well circular as longitudinal. The second stomach or gizzard has outwardly the shape of the stomach of a man; and upon opening is always found filled with a variety of discordant substances; hay, grass, barley, beans, bones, and stones, some of which exceed in size a pullet's egg. The kidneys are eight inches long and two broad, and differ from those of other birds in not being divided into lobes. The heart and lungs are separated by a midriff as in quadrupeds; and the parts of generation also bear a very strong resemblance and analogy.

The ostrich is a native only of the torrid regions of Africa, and has long been celebrated by those who have had occasion to mention the animals of that region. Its flesh is proscribed in Scripture as unfit to be eaten; and most of the ancient writers describe it as well known in their times. Like the race of the elephant, it is transmitted down without mixture; and has never been known to breed out of that country which first produced it. It seems formed to live among the sandy and burning deserts of the torrid zone; and, as in some measure it owes its birth to their genial influence, so it seldom migrates into tracts more mild or more fertile. The Arabians assert that the ostrich never

drinks; and the place of its habitation seems to confirm the assertion. In these formidable regions ostriches are seen in large flocks, which to the distant spectator appear like a regiment of cavalry, and have often alarmed a whole caravan. There is no desert, how barren soever, but what is capable of supplying these animals with provision; they eat almost every thing; and these barren tracts are thus doubly grateful, as they afford both food and security. The ostrich is of all other animals the most voracious. It will devour leather, grass, hair, iron, stones, or any thing that is given. Those substances which the coats of the stomach cannot soften, pass whole; so that glass, stones, or iron, are excluded in the form in which they were devoured. In an ostrich dissected by Ranby, there appeared such a quantity of heterogeneous substances, that it was wonderful how any animal could digest such an overcharge of nourishment. Valsineri also found the first stomach filled with a quantity of incongruous substances; grass, nuts, cords, stones, glass, brass, copper, iron, tin, lead, and wood; a piece of stone was found among the rest that weighed more than a pound. He saw one of these animals that was killed by devouring a quantity of quicklime. It would seem that the ostrich is obliged to fill up the great capacity of its stomach in order to be at ease; but that nutritious substances not occurring, it pours in whatever offers to supply the void.

In their native deserts, however, it is probable they live chiefly upon vegetables, where they lead an inoffensive and social life; the male, as Thevenot assures us, assorting with the female with connubial fidelity. They are said to be very much inclined to venery; and the make of the parts in both sexes seems to confirm the report. It is probable also they copulate like other birds, by compression. They lay very large eggs, some of them being above five inches in diameter, and weighing above fifteen pounds. These eggs have a very hard shell, somewhat resembling those of the crocodile, except that those of the latter are less and rounder.

The season for laying depends on the climate where the animal is bred. In the northern parts of Africa, this season is about the beginning of July; in the south, it is about the latter end of December. These birds are very prolific, and lay generally from 40 to 50 eggs at one clutch, which are as big as a child's head. It has been commonly reported, that the female deposits them in the sand, and covering them up, leaves them to be hatched by the heat of the climate, and then permits the young to shift for themselves. Very little of this, however, is true: no bird has a stronger affection for her young than the ostrich, nor none watches her eggs with greater assiduity. It happens, indeed, in those hot climates, that there is less necessity for the continual incubation of the female; and she more frequently leaves her eggs, which are in no danger of being chilled by the weather: but though she sometimes forsakes them by day, she always carefully broods over them by night; and Kolben, who has seen great numbers of them at the Cape of Good Hope, affirms, that they sit on their eggs like other birds, and that the male and the female take this office by turns, as he had frequent opportunities of observing. Nor is it more true what is said of their forsaking their young after they are excluded the shell. On the contrary, the young ones are not even able to walk for several days after they are hatched. During this time the old ones are very assiduous in supplying them with grass, and very careful to defend them from danger; nay, they encounter every danger in their defence. The young, when brought forth, are of an ash-colour the first year, and are covered with feathers all over. But in time these feathers drop; and those parts which

Struthio, which are covered assume a different and more becoming plumage.

The beauty of a part of this plumage, particularly the long feathers that compose the wings and tail, is the chief reason that man has been so active in pursuing this harmless bird to its deserts, and hunting it with no small degree of expence and labour. The ancients used those plumes in their helmets; our military wear them in their hats; and the ladies make them an ornament in their dresses. Those feathers which are plucked from the animal while alive are much more valued than those taken when dead, the latter being dry, light, and subject to be worm-eaten.

Beside the value of their plumage, some of the savage nations of Africa hunt them also for their flesh; which they consider as a dainty. They sometimes also breed these birds tame, to eat the young ones, of which the females are said to be the greatest delicacy. Some nations have obtained the name of *Struthophagi*, or *ostrich eaters*, from their peculiar fondness for this food; and even the Romans themselves were not averse to it. Even among the Europeans now, the eggs of the ostrich are said to be well-tasted, and extremely nourishing; but they are too scarce to be fed upon, although a single egg be a sufficient entertainment for eight men.

As the spoils of the ostrich are thus valuable, it is not to be wondered at that man has become their most assiduous pursuer. For this purpose, the Arabians train up their best and fleetest horses, and hunt the ostrich still in view. Perhaps, of all other varieties of the chase, this, though the most laborious, is yet the most entertaining. As soon as the hunter comes within sight of his prey, he puts on his horse with a gentle gallop, so as to keep the ostrich still in sight; yet not so as to terrify him from the plain into the mountains. Of all known animals, the ostrich is by far the swiftest in running; upon observing himself, therefore, pursued at a distance, he begins to run at first but gently; either insensible of his danger, or sure of escaping. In this situation, he somewhat resembles a man at full speed; his wings, like two arms, keep working with a motion correspondent to that of his legs; and his speed would very soon snatch him from the view of his pursuers; but, unfortunately for the silly creature, instead of going off in a direct line, he takes his course in circles; while the hunters still make a small course within, relieve each other, meet him at unexpected turns, and keep him thus still employed, still followed, for two or three days together. At last, spent with fatigue and famine, and finding all power of escape impossible, he endeavours to hide himself from those enemies he cannot avoid, and covers his head in the sand or the first thicket he meets. Sometimes, however, he attempts to face his pursuers; and though in general the most gentle animal in nature, when driven to desperation he defends himself with his beak, his wings, and his feet. Such is the force of his motion, that a man would be utterly unable to withstand him in the shock.

The *Struthophagi* have another method of taking this bird: they cover themselves with an ostrich's skin, and passing up an arm through the neck, thus counterfeit all the motions of this animal. By this artifice they approach the ostrich, which becomes an easy prey. He is sometimes also taken by dogs and nets; but the most usual way is that mentioned above.

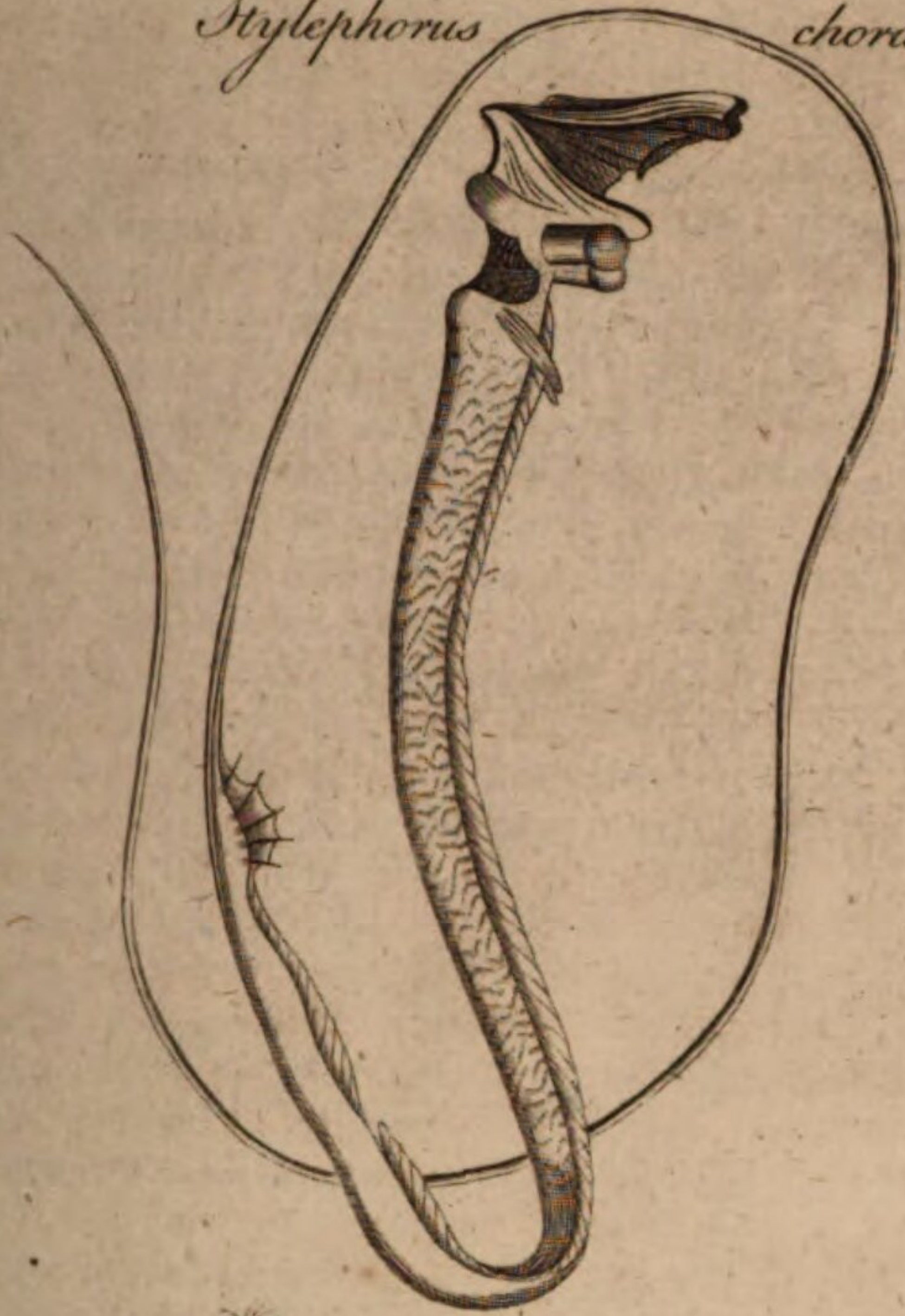
When the Arabians have thus taken an ostrich, they cut its throat; and making a ligament below the opening, they shake the bird as one would rinse a barrel; then taking off the ligature, there runs out from the wound in the throat a considerable quantity of blood mixed with the fat of the animal; and this is considered as one of their greatest dainties.

They next flea the bird; and of the skin, which is strong and thick, sometimes make a kind of vest, which answers the purposes of a cuirass and a buckler.

There are others who, more compassionate or more provident, do not kill their captive, but endeavour to tame it, for the purposes of supplying those feathers which are in so great request. The inhabitants of Dara and Lybia breed up whole flocks of them, and they are tamed with very little trouble. But it is not for their feathers alone that they are prized in this domestic state; they are often ridden upon and used as horses. Moore assures us, that at Joar he saw a man travelling upon an ostrich; and Adanson asserts, that at the factory of Podore he had two ostriches, which were then young, the strongest of which ran swifter than the best English racer, although he carried two negroes on his back. As soon as the animal perceived that it was thus loaded, it set off running with all its force, and made several circuits round the village; till at length the people were obliged to stop it by barring up the way. How far this strength and swiftness may be useful to mankind, even in a polished state, is a matter that perhaps deserves inquiry.

II. The *CASSOWARY* (the *Casuarus* of Linnæus, and *Galeated Cassowary* of Dr Latham) was first brought into Europe from Java by the Dutch about the year 1597. It is nearly equal in size to the ostrich, but its legs are much thicker and stronger in proportion. This conformation gives it an air of strength and force, which the fierceness and singularity of its countenance conspire to render formidable. It is five feet and an half long from the point of the bill to the extremity of the claws. The legs are two feet and an half high from the belly to the end of the claws. The head and neck together are a foot and an half; and the largest toe, including the claw, is five inches long. The claw alone of the least toe is three inches and a half in length. The wing is so small that it does not appear, it being hid under the feathers of the back. In other birds, a part of the feathers serve for flight, and are different from those that serve merely for covering; but in the cassowary all the feathers are of the same kind, and outwardly of the same colour. They are generally double, having two long shafts, which grow out of a short one, which is fixed in the skin. Those that are double are always of an unequal length; for some are 14 inches long, particularly on the rump, while others are not above three. The beards that adorn the stem or shaft are about half-way to the end, very long, and as thick as an horse-hair, without being subdivided into fibres. The stem or shaft is flat, shining, black, and knotted below; and from each knot there proceeds a beard; likewise the beards at the end of the large feathers are perfectly black, and towards the root of a grey tawny colour; shorter, more soft, and throwing out fine fibres like down; so that nothing appears except the ends, which are hard and black; because the other part, composed of down, is quite covered. There are feathers on the head and neck; but they are so short and thinly sown, that the bird's skin appears naked, except towards the hinder part of the head, where they are a little longer. The feathers which adorn the rump are extremely thick; but do not differ in other respects from the rest, excepting their being longer. The wings, when they are deprived of their feathers, are but three inches long; and the feathers are like those on other parts of the body. The ends of the wings are adorned with five prickles, of different lengths and thickness, which bend like a bow: these are hollow from the roots to the very points, having only that slight substance within which all quills are known to have. The longest of these prickles is 11 inches; and it is a quarter of an inch in diameter at the root, being thicker there than towards the extremity; the point seems broken off.

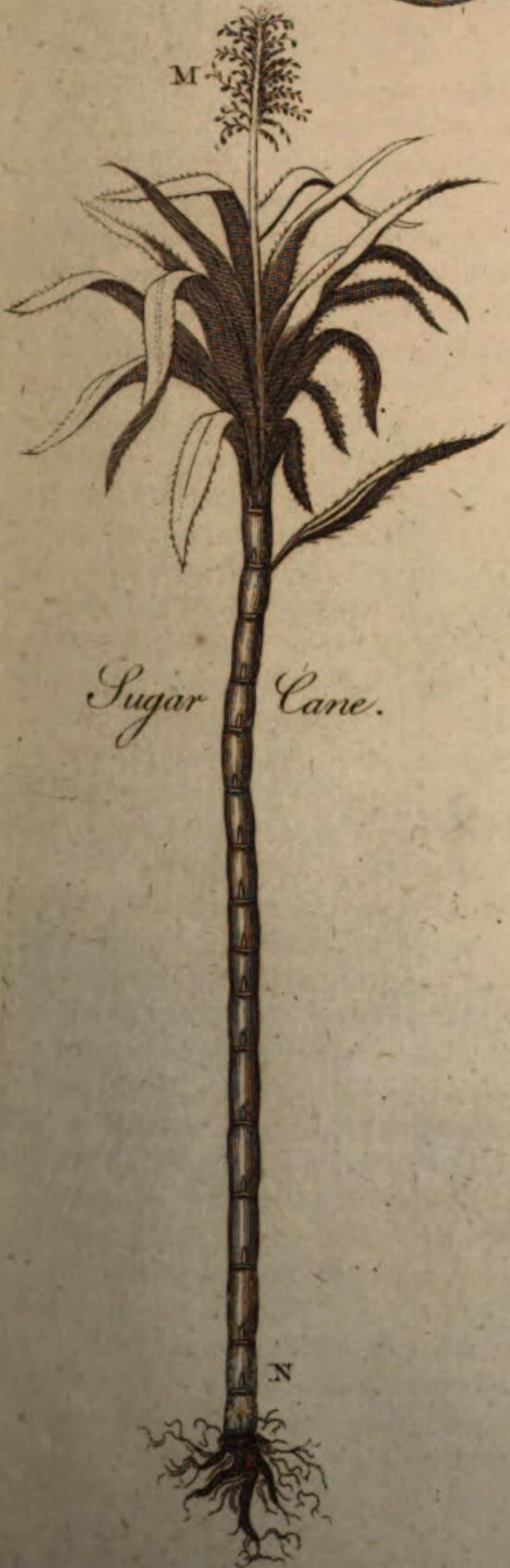
Stylephorus chordatus.



Styrac Benzoin.



M



Sugar Cane.

Struthio (Cstrich.)



Struthio. The part, however, which most distinguishes this animal is the head: which, though small, like that of an ostrich, does not fail to inspire some degree of terror. It is bare of feathers, and is in a manner armed with an helmet of horny substance, that covers it from the root of the bill to near half the head backwards. This helmet is black before and yellow behind. Its substance is very hard, being formed by the elevation of the bone of the skull; and it consists of several plates, one over another, like the horn of an ox. Some have supposed that this was shed every year with the feathers; but the most probable opinion is, that it only exfoliates slowly like the beak. To the peculiar oddity of this natural armour may be added the colour of the eye in this animal, which is a bright yellow; and the globe being above an inch and a half in diameter, give it an air equally fierce and extraordinary. The hole of the ear is very large and open, being only covered with small black feathers. The sides of the head, about the eye and ear, being destitute of any covering, are blue, except the middle of the lower eyelid, which is white. The part of the bill which answers to the upper jaw in other animals is very hard at the edges above, and the extremity of it is like that of a turkey-cock. The end of the lower mandible is slightly notched, and the whole is of a greyish brown, except a green spot on each side. As the beak admits a very wide opening, this contributes not a little to the bird's menacing appearance. The neck is of a violet colour, inclining to that of slate; and it is red behind in several places, but chiefly in the middle. About the middle of the neck before, at the rise of the large feathers, there are two processes formed by the skin, which resemble somewhat the gills of a cock, but that they are blue as well as red. The skin which covers the forepart of the breast, on which this bird leans and rests, is hard, callous, and without feathers. The thighs and legs are covered with feathers, and are extremely thick, strong, straight, and covered with scales of several shapes; but the legs are thicker a little above the foot than in any other place. The toes are likewise covered with scales, and are but three in number; for that which should be behind is wanting. The claws are of a hard solid substance, black without and white within.

The internal parts are equally remarkable. The cassowary unites with the double stomach of animals that live upon vegetables the short intestines of those that live upon flesh. The intestines of the cassowary are 13 times shorter than those of the ostrich. The heart is very small, being but an inch and an half long, and an inch broad at the base. Upon the whole, it has the head of a warrior, the eye of a lion, the defence of a porcupine, and the swiftness of a courser.

Thus formed for a life of hostility, for terrifying others, and for its own defence, it might be expected that the cassowary was one of the most fierce and terrible animals of the creation. But nothing is so opposite to its natural character: it never attacks others; and instead of the bill, when attacked, it rather makes use of its legs, and kicks like a horse, or runs against its pursuer, beats him down, and treads him to the ground.

The manner in which this animal moves is not less extraordinary than its appearance. Instead of going directly forward, it seems to kick up behind with one leg; and then making a bound onward with the other, it goes with such prodigious velocity, that the swiftest racer would be left far behind.

The same degree of voraciousness which we perceived in the ostrich obtains as strongly here. The cassowary swallows every thing that comes within the capacity of its gullet. The Dutch assert, that it can devour not only glass,

iron, and stones, but even live and burning coals, without testifying the smallest fear or feeling the least injury. It is said, that the passage of the food through its gullet is performed so speedily, that even the very eggs which it has swallowed whole pass through it unbroken in the same form they went down. In fact, the alimentary canal of this animal, as was observed above, is extremely short; and it may happen, that many kinds of food are indigestible in its stomach, as wheat or currants are to man, when swallowed whole.

The cassowary's eggs are of a grey-ash colour, inclining to green. They are not so large nor so round as those of the ostrich. They are marked with a number of little tubercles of a deep green, and the shell is not very thick. The largest of these is found to be 15 inches round one way, and about 12 the other.

The southern parts of the most eastern Indies seem to be the natural climate of the cassowary. His domain, if we may so call it, begins where that of the ostrich terminates. The latter has never been found beyond the Ganges; while the cassowary is never seen nearer than the islands of Banda, Sumatra, Java, the Molucca islands, and the corresponding parts of the continent. Yet even here this animal seems not to have multiplied in any considerable degree, as we find one of the kings of Java making a present of one of these birds to the captain of a Dutch ship, considering it as a very great rarity.

2. The *Casuarus Nova Hollandie*, or New Holland cassowary, differs considerably from the common cassowary. It is a much larger bird, standing higher on its legs, and having the neck longer than in the common one. Total length seven feet two inches. The bill is not greatly different from that of the common cassowary; but the horny appendage or helmet on the top of the head in this species is totally wanting: the whole of the head and neck is also covered with feathers, except the throat and fore part of the neck about half way, which are not so well feathered as the rest; whereas in the common cassowary the head and neck are bare and carunculated as in the turkey.

The plumage in general consists of a mixture of brown and grey, and the feathers are somewhat curled or bent at the ends in the natural state: the wings are so very short as to be totally useless for flight, and indeed are scarcely to be distinguished from the rest of the plumage, were it not for their standing out a little. The long spines which are seen in the wings of the common sort are in this not observable, nor is there any appearance of a tail. The legs are stout, formed much as in the galeated cassowary, with the addition of their being jagged or sawed the whole of their length at the back part.

This bird is not uncommon in New Holland, as several of them have been seen about Botany Bay and other parts. Although it cannot fly, it runs so swiftly, that a greyhound can scarcely overtake it. The flesh is said to be in taste not unlike beef.

STRUTHIOLA, in botany; a genus of plants belonging to the class of *tetrandria*, and order of *monogynia*. The corolla is wanting; the calyx is tubulous, with eight glandules at its mouth; the berry is without juice, and monospermous. The species are three, the *virgata*, *erecta*, and *nana*, all of foreign extraction.

STRYCHNOS, in botany: A genus of plants belonging to the class of *pentandria*, and order of *monogynia*; and in the natural system ranging under the 28th order, *Lurida*. The corolla is quinquefid; the berry is unilocular, with a woody bark. The species are three, the *nux vomica*, *colubrina*, and *potatorum*, natives of foreign countries.

STRYMON (anc. geog.), formerly *Conozus*; a river constituting

Struthio

Strymon.

Governor
Phillip's
Voyage to
Botany Bay.

Strype,
Stuart.

stituting the ancient limits of Macedonia and Thrace; rising in mount Scombrus (Aristotle). Authors differ as to the modern name of this river.

STRYPE (John), was descended from a German family, born at London, and educated at Cambridge. He was vicar of Low Layton in Essex, and distinguished himself by his compilations of Lives and Memoirs; in which, as Dr Birch remarks, his fidelity and industry will always give a value to his writings, however destitute they may be of the graces of style. He died in 1737, after having enjoyed his vicarage near 68 years.

STUART (Dr Gilbert), was born at Edinburgh in the year 1742. His father Mr George Stuart was professor of humanity in the university, and a man of considerable eminence for his classical taste and literature. For these accomplishments he was probably indebted in no small degree to his relation the celebrated Ruddiman, with whom both he and his son conversed familiarly, though they afterwards united to injure his fame.

Gilbert having finished his classical and philosophical studies in the grammar-school and university, applied himself to jurisprudence, without following or probably intending to follow the profession of the law. For that profession he has been represented as unqualified by indolence; by a passion which at a very early period of life he displayed for general literature; or by boundless dissipation:—and all these circumstances may have contributed to make him relinquish pursuits in which he could hope to succeed only by patient perseverance and strict decorum of manners. That he did not waste his youth in idleness, is, however, evident from *An Historical Dissertation concerning the Antiquity of the British Constitution*, which he published before he had completed his twenty-second year, and which had so much merit as to induce the university of Edinburgh to confer upon the author, though so young a man, the degree of LL.D.

After a studious interval of some years, he produced a valuable work, under the title of *A View of Society in Europe, in its Progress from Rudeness to Refinement*; or, *Inquiries concerning the History of Laws, Government, and Manners*. He had read and meditated with patience on the most important monuments of the middle ages; and in this volume (which speedily reached a second edition) he aimed chiefly at the praise of originality and invention, and discovered an industry that is seldom connected with ability and discernment. About the time of the publication of the first edition of this performance, having turned his thoughts to an academical life, he asked for the professorship of public law in the university of Edinburgh. According to his own account he had been promised that place by the minister, but had the mortification to see the professorship bestowed on another, and all his hopes blasted by the influence of Dr Robertson, whom he represented as under obligations to him.

To the writer of this article, who was a stranger to these rival candidates for historical fame, this part of the story seems very incredible; as it is not easy to conceive how it ever could be in the power of Dr Stuart to render to the learned Principal any essential service. It was believed indeed by the earl of Buchan, and by others, who observed that the illiberal jealousy not unfrequent in the world of letters, was probably the source of this opposition; which entirely broke the intimacy of two persons who, before that time, were understood to be on the most friendly footing with each other. Ingratitude, however, is as likely to have

* Chalmers
in his Life
of Ruddi-
man.

been the vice of Dr Stuart as of Dr Robertson; for we have been told by a writer*, who, at least in one instance, has completely proved what he affirms, that "such was Gil-

bert Stuart's laxity of principle as a man, that he considered ingratitude as one of the most venial sins; such was his conceit as a writer, that he regarded no one's merits but his own; such were his disappointments, both as a writer and a man, that he allowed his peevishness to four into malice, and indulged his malevolence till it settled in corruption."

Soon after this disappointment Dr Stuart went to London, where he became from 1768 to 1774 one of the writers of the *Monthly Review*. In 1772 Dr Adam, rector of the high-school at Edinburgh, published a Latin Grammar, which he intended as an improvement of the famous Ruddiman's. Stuart attacked him in a pamphlet under the name of *Busby*, and treated him with much severity. In doing this, he was probably actuated more by some personal dislike of Dr Adam than by regard for the memory of his learned relation; for on other occasions he showed sufficiently that he had no regard to Ruddiman's honour as a grammarian, editor, or critic.

In 1774 he returned to his native city, and began the *Edinburgh Magazine and Review*, in which he discussed the liberty and constitution of England, and distinguished himself by an inquiry into the character of John Knox the reformer, whose principles he reprobated in the severest terms. About this time he revised and published *Sullivan's Lectures on the Constitution of England*. Soon after he turned his thoughts to the history of Scotland, and published *Observations concerning its Public Law and Constitutional History*; in which he examined with a critical care the preliminary book to Dr Robertson's History. His next work was *The History of the Reformation*; a book which deserves praise for the easy dignity of the narrative, and for strict impartiality. His last great work, *The History of Scotland from the Establishment of the Reformation to the Death of Queen Mary*, which appeared in 1782, has been very generally read and admired. His purpose was to vindicate the character of the injured queen, and expose the weakness of the arguments by which Dr Robertson had endeavoured to prove her guilty: but though the style of this work is his own, it contains very little matter which was not furnished by Goodall and Tytler; and it is with the arms which these two writers put into his hands that Dr Stuart vanquished his great antagonist.

In 1782 he once more visited London, and engaged in the *Political Herald and English Review*; but the jaundice and dropsy increasing on him, he returned by sea to his native country, where he died in the house of his father on the 13th of August 1786.

In his person Dr Stuart was about the middle size and justly proportioned. His countenance was modest and expressive, sometimes glowing with sentiments of friendship, of which he was truly susceptible, and at others darting that satire and indignation at folly and vice which appear in some of his writings. He was a boon companion; and, with a constitution that might have stood the shock of ages, he fell a premature martyr to intemperance. His talents were certainly great, and his writings are useful; but he seems to have been influenced more by passion than prejudice, and in his character there was not much to be imitated.

STUCCO, in building, a composition of white marble pulverised, and mixed with plaster of lime; and the whole being sifted and wrought up with water, is to be used like common plaster: this is called by Pliny *marmoratum opus*, and *albarium opus*.

A patent has been granted to Mr B. Higgins for inventing a new kind of stucco, or water-cement, more firm and durable than any heretofore. Its composition, as extracted

Stuart,
Stucco.

Stucco. tracted from the specification signed by himself, is as follows: "Drift-sand, or quarry (A) sand, which consists chiefly of hard quartose flat-faced grains with sharp angles; which is the freest, or may be most easily freed by washing, from clay, salts, and calcareous, gypseous, or other grains less hard and durable than quartz; which contains the smallest quantity of pyrites or heavy metallic matter inseparable by washing; and which suffers the smallest diminution of its bulk in washing in the following manner—is to be preferred before any other. And where a coarse and a fine sand of this kind, and corresponding in the size of their grains with the coarse and fine sands hereafter described, cannot be easily procured, let such sand of the foregoing quality be chosen as may be sorted and cleansed in the following manner:

"Let the sand be sifted in streaming clear water, thro' a sieve which shall give passage to all such grains as do not exceed one-sixteenth of an inch in diameter; and let the stream of water and the sifting be regulated so that all the sand, which is much finer than the Lynn-sand commonly used in the London glass-houses, together with clay and every other matter specifically lighter than sand, may be washed away with the stream, whilst the purer and coarser sand, which passes through the sieve, subsides in a convenient receptacle, and whilst the coarse rubbish and rubble remain on the sieve to be rejected.

"Let the sand which thus subsides in the receptacle be washed in clean streaming water through a finer sieve, so as to be further cleansed and sorted into two parcels; a coarser, which will remain in the sieve which is to give passage to such grains of sand only as are less than one-thirtieth of an inch in diameter, and which is to be saved apart under

the name of *coarse sand*; and a finer, which will pass thro' the sieve and subside in the water, and which is to be saved apart under the name of *fine sand*.—Let the coarse and the fine sand be dried separately, either in the sun or on a clean iron-plate, set on a convenient surface, in the manner of a sand-heat (B).

"Let lime be chosen (C) which is stone-lime, which heats the most in slaking, and flakes the quickest when duly watered; which is the freshest made and closest kept; which dissolves in distilled vinegar with the least effervescence, and leaves the smallest residue insoluble, and in this residue the smallest quantity of clay, gypsum, or martial matter.

"Let the lime chosen according to these important rules be put in a brass-wired sieve to the quantity of 14 pounds. Let the sieve be finer than either of the foregoing; the finer, the better it will be: let the lime be slaked (D) by plunging it in a butt filled with soft water, and raising it out quickly and suffering it to heat and fume, and by repeating this plunging and raising alternately, and agitating the lime, until it be made to pass through the sieve into the water; and let the part of the lime which does not easily pass through the sieve be rejected: and let fresh portions of the lime be thus used, until as many (E) ounces of lime have passed through the sieve as there are quarts of water in the butt. Let the water thus impregnated stand in the butt closely covered (F) until it becomes clear; and through wooden (G) cocks placed at different heights in the butt, let the clear liquor be drawn off as fast (H) and as low as the lime subsides, for use. This clear liquor I call the *cementing liquor* (I). The freer the water is from saline matter, the better will be the cementing liquor made with it.

F 2

"Let

(A) "This is commonly called *pit-sand*.

(B) "The sand ought to be stirred up continually until it is dried, and is then to be taken off; for otherwise the evaporation will be very slow, and the sand which lies next the iron plate, by being overheated, will be discoloured.

(C) "The preference given to stone-lime is founded on the present practice in the burning of lime, and on the closer texture of it, which prevents it from being so soon injured by exposure to the air as the more spongy chalk-lime is; not on the popular notion that stone-lime has something in it whereby it excels the best chalk in the cementing properties. The gypsum contained in lime-stone remains unaltered, or very little altered, in the lime, after the burning; but it is not to be expected that clay or martial matter should be found in their native state in well-burned lime; for they concrete or vitrify with a part of the calcareous earth, and constitute the hard grains or lumps which remain undissolved in weak acids, or are separable from the slaked lime by sifting it immediately through a sieve.

(D) "This method of impregnating the water with lime is not the only one which may be adopted. It is, however, preferred before others, because the water clears the sooner in consequence of its being warmed by the slaking lime; and the gypseous part of the lime does not diffuse itself in the water so freely in this way as it does when the lime is slaked to fine powder in the common method, and is then blended with the water; for the gypseous part of the lime flakes at first into grains rather than into fine powder, and will remain on the sieve after the pure lime has passed through, long enough to admit of the intended separation; but when the lime is otherwise slaked, the gypseous grains have time to flake to a finer powder, and passing through the sieve, dissolve in the water along with the lime. I have imagined that other advantages attended this method of preparing the lime-water, but I cannot yet speak of them with precision.

(E) "If the water contains no more acidulous gas than is usually found in river or rain water, a fourth part of this quantity of lime, or less, will be sufficient.

(F) "The calcareous crust which forms on the surface of the water ought not to be broke, for it assists in excluding the air, and preventing the absorption of acidulous gas whereby the lime-water is spoiled.

(G) "Brass-cocks are apt to colour a part of the liquor.

(H) "Lime-water cannot be kept many days unimpaired, in any vessels that are not perfectly air-tight. If the liquor be drawn off before it clears, it will contain whiting, which is injurious; and if it be not instantly used after it is drawn limpid from the butt into open vessels, it will grow turbid again, and deposit the lime changed to whiting by the gas absorbed from the air. The calcareous matter which subsides in the butt resembles whiting the more nearly as the lime has been more sparingly employed; in the contrary circumstances, it approaches to the nature of lime; and in the intermediate state, it is fit for the common composition of the plasterers for inside stucco.

(I) "At the time of writing this specification, I preferred this term before that of lime-water, on grounds which I had not sufficiently examined.

Stucco.

" Let 56 pounds of the aforesaid chosen lime be flaked, by gradually sprinkling on it, and especially on the unflaked pieces, the cementing liquor, in a close (κ) clean place. Let the flaked part be immediately (L) sifted through the last-mentioned fine brass-wired sieve: Let the lime which passes be used instantly, or kept in air-tight vessels, and let the part of the lime which does not pass through the sieve be rejected (M).—This finer richer part of the lime which passes through the sieve I call *purified lime*.

" Let bone-ash be prepared in the usual manner, by grinding the whitest burnt bones, but let it be sifted, to be much finer than the bone-ash commonly sold for making cupels.

" The most eligible materials for making my cement being thus prepared, take 56 pounds of the coarse sand and 42 pounds of the fine sand; mix them on a large plank of hard wood placed horizontally; then spread the sand so that it may stand to the height of six inches, with a flat surface on the plank; wet it with the cementing liquor; and let any superfluous quantity of the liquor, which the sand in the condition described cannot retain, flow away off the plank. To the wettest sand add 14 pounds of the putrefied lime in several successive portions, mixing and beating them up together in the mean time with the instruments generally used in making fine mortar: then add 14 pounds of the bone-ash in successive portions, mixing and beating all together. The quicker and the more perfectly these materials are mixed and beaten together, and the sooner the cement thus formed is used, the better (N) it will be. This I call the *water-cement coarse-grained*, which is to be applied in building, pointing, plastering, stuccoing, or other work, as mortar and stucco now are; with this difference chiefly, that as this cement is shorter than mortar or common stucco, and dries sooner, it ought to be worked expeditiously in all cases; and in stuccoing, it ought to be laid on by sliding the trowel upwards on it; that the materials used along with this cement in building, or the ground on which it is to be laid in stuccoing, ought to be well wetted with the cementing liquor in the instant of laying on the cement; and that the cementing liquor is to be used when it is necessary to moisten the cement, or when a liquid is required to facilitate the floating of the cement.

" When such cement is required to be of a finer texture,

take 98 pounds of the fine sand, wet it with the cementing liquor, and mix it with the purified lime and the bone-ash in the quantities and in the manner above described; with this difference only, that 15 pounds of lime, or (O) thereabouts, are to be used instead of 14 pounds, if the greater part of the sand be as fine as Lynn sand. This I call *water-cement fine-grained*. It is to be used in giving the last coating, or the finish to any work intended to imitate the finer-grained stones or stucco: But it may be applied to all the uses of the water-cement coarse grained, and in the same manner.

" When for any of the foregoing purposes of pointing, building, &c. such a cement is required much cheaper and coarser-grained, then much coarser clean sand than the foregoing coarse sand, or well-washed fine rubble, is to be provided. Of this coarse sand or rubble take 56 pounds, of the foregoing coarse sand 28 pounds, and of the fine sand 14 pounds; and after mixing these, and wetting them with the cementing liquor in the foregoing manner, add 14 pounds, or somewhat less, of the (P) purified lime, and then 14 pounds or somewhat less of the bone-ash, mixing them together in the manner already described. When my cement is required to be white, white sand, white lime, and the whitest bone-ash are to be chosen. Grey sand, and grey bone-ash formed of half-burnt bones, are to be chosen to make the cement grey; and any other colour of the cement is obtained, either by choosing coloured sand, or by the admixture of the necessary quantity of coloured talc in powder, or of coloured, vitreous, or metallic powders, or other durable colouring ingredients commonly used in paint.

" To the end that such a water-cement as I have described may be made as useful as it is possible in all circumstances; and that no person may imagine that my claim and right under these letters-patent may be eluded by divers variations, which may be made in the foregoing process without producing any notable defect in the cement; and to the end that the principles of this art, as well as the art itself, of making my cement, may be gathered from this specification and perpetuated to the public; I shall add the following observations:

" This my water-cement, whether the coarse or fine grained, is applicable in forming artificial stone, by making alternate layers of the cement and of flint, hard stone, or brick,

(κ) " The vapour which arises in the flaking of lime contributes greatly to the flaking of these pieces which lie in its way; and an unnecessary waste of the liquor is prevented, by applying it to the lime heaped in a pit or in a vessel, which may restrain the issue of the vapour, and direct it through the mass. If more of the liquor be used than is necessary to flake the lime, it will create error in weighing the flaked powder, and will prevent a part of it from passing freely thro' the sieve. The liquid is therefore to be used sparingly, and the lime which has escaped its action is to be sprinkled apart with fresh liquor.

(L) " When the aggregation of the lumps of lime is thus broken, it is impaired much sooner than it is in the former state, because the air more freely pervades it.

(M) " Because it consists of heterogeneous matter or of ill-burnt lime; which last will flake and pass through the sieve, if the lime be not immediately sifted after the flaking, agreeable to the text.

(N) " These proportions are intended for a cement made with sharp sand, for incrustation in exposed situations, where it is necessary to guard against the effects of hot weather and rain. In general, half this quantity of bone-ashes will be found sufficient; and although the incrustation in this latter case will not harden deeply so soon, it will be ultimately stronger, provided the weather be favourable.

" The injuries which lime and mortar sustain by exposure to the air, before the cement is finally placed in a quiescent state, are great; and therefore our cement is the worse for being long beaten, but the better as it is quickly beaten until the mixture is effected, and no longer.

(O) " The quantity of bone-ashes is not to be increased with that of the lime; but it is to be lessened as the exposure and purposes of the work will admit.

(P) " Because less lime is necessary, as the sand is coarser.

Stucco.

Stucco. brick, in moulds of the figure of the intended stone, and by exposing the masses so formed to the open (Q) air to harden.

"When such cement is required for water-(R) fences, two-thirds of the prescribed quantity of bone-ashes are to be omitted; and in the place thereof an equal measure of powdered terras is to be used; and if the sand-employed be not of the coarsest sort, more terras must be added, so that the terras shall be by weight one-sixth part of the weight of the sand.

"When such a cement is required of the finest grain (S) or in a fluid form, so that it may be applied with a brush, flint powder, or the powder of any quartose or hard earthy substance, may be used in the place of sand; but in a quantity smaller, as the flint or other powder is finer; so that the flint-powder, or other such powder, shall not be more than six times the weight of the lime, nor less than four times its weight. The greater the quantity of lime within these limits, the more will the cement be liable to crack by quick-drying, and *vice versa*.

"Where such sand as I prefer cannot be conveniently procured, or where the sand cannot be conveniently washed and sorted, that sand which most resembles the mixture of coarse and fine sand above prescribed, may be used as I have directed, provided due attention is paid to the quantity of the lime, which is to be greater (T) as the quantity is finer, and *vice versa*.

"Where sand cannot be easily procured, any durable stony body, or baked earth grossly powdered (U), and sorted nearly to the sizes above prescribed for sand, may be used in the place of sand, measure for measure, but not weight for weight, unless such gross powder be as heavy specifically as sand.

"Sand may be cleansed from every softer, lighter, and less durable matter, and from that part of the sand which is too fine, by various methods preferable (X), in certain circumstances, to that which I have described.

"Water may be found naturally free from fixable gas,

felenite, or clay; such water may, without any notable inconvenience, be used in the place of the cementing liquor; and water approaching this state will not require so much lime as I have ordered to make the cementing liquor; and a cementing liquor sufficiently useful may be made by various methods of mixing lime and water in the described proportions, or nearly so.

"When stone-lime cannot be procured, chalk-lime, or shell-lime, which best resembles stone-lime, in the characters above written of lime, may be used in the manner described, except that fourteen pounds and a half of chalk-lime will be required in the place of fourteen pounds of stone-lime. The proportion of lime which I have prescribed above may be increased without inconvenience, when the cement or stucco is to be applied where it is not liable to dry quickly; and in the contrary circumstance, this proportion may be diminished; and the defect of lime in quantity or quality may be very advantageously supplied (Y), by causing a considerable quantity of the cementing liquor to soak into the work, in successive portions, and at distant intervals of time, so that the calcareous matter of the cementing liquor, and the matter attracted from the open air, may fill and strengthen the work.

"The powder of almost every well-dried or burnt animal substance may be used instead of bone-ash; and several earthy powders, especially the micaceous and the metallic; and the elixated ashes of divers vegetables whose earth will not burn to lime; and the ashes of mineral fuel, which are of the calcareous kind, but will not burn to lime, will answer the ends of bone-ash in some degree.

"The quantity of bone-ash described may be lessened without injuring the cement, in those circumstances especially which admit the quantity of lime to be lessened, and in those wherein the cement is not liable to dry quickly. And the art of remedying the defects of lime may be advantageously practised to supply the deficiency of bone-ash, especially in building, and in making artificial stone with this cement.

STUD.

(Q) "But they must not be exposed to the rain until they are almost as strong as fresh Portland stone; and even then they ought to be sheltered from it as much as the circumstances will admit. These stones may be made very hard and beautiful, with a small expence of bone-ash, by soaking them, after they have dried thoroughly and hardened, in the lime liquor, and repeating this process twice or thrice, at distant intervals of time. The like effect was experienced in incrustations.

(R) "In my experiments, mortar made with terras-powder, in the usual method, does not appear to form so strong a cement for water-fences as that made, according to the specification, with coarse sand; and I see no more reason for avoiding the use of sand in terras-mortar, than there would be for rejecting stone from the embankment. The bone-ashes meant in this place are the dark grey or black sort. I am not yet fully satisfied about the operation of them in this instance.

(S) "The qualities and uses of such fine calcareous cement are recommended chiefly for the purpose of smoothing and finishing the stronger crustaceous works, or for washing walls to a lively and uniform colour. For this last intention, the mixture must be as thin as new cream, and laid on briskly with a brush, in dry weather; and a thick and durable coat is to be made by repeated washing; but is not to be attempted by using a thicker liquor; for the coat made with this last is apt to scale, whilst the former endures the weather much longer than any other thin calcareous covering that has been applied in this way. Fine yellow-ochre is the cheapest colouring ingredient for such wash, when it is required to imitate Bath-stone, or the warm-white stones.

(T) "If sea-sand be well washed in fresh water, it is as good as any other round sand.

(U) "The cement made with these and the proper quantities of purified lime and lime-water, are inferior to the best, as the grains of these powders are more perishable and brittle than those of sand. They will not therefore be employed, unless for the sake of evasion, or for want of sand: in this latter case, the finer powder ought to be washed away.

(X) "This and the next paragraph is inserted with a view to evasions, as well as to suggest the easier and cheaper methods which may be adopted in certain circumstances, by artists who understand the principles which I endeavoured to teach.

(Y) "This practice is noticed, as the remedy which may be used for the defects arising from evasive measures, and as the method of giving spongy incrustations containing bone-ashes the greatest degree of hardness."

Stud
Sturmius.

STUD, in the manege, a collection of breeding horses and mares.

STUDDING-SAILS, certain light sails extended, in moderate and steady breezes, beyond the skirts of the principal sails, where they appear as wings upon the yard-arms.

STUFF, in commerce, a general name for all kinds of fabrics of gold, silver, silk, wool, hair, cotton, or thread, manufactured on the loom; of which number are velvets, brocades, mohairs, satins, taffetas, cloths, serges, &c.

STUKELY (Dr William), a celebrated antiquarian, descended from an ancient family in Lincolnshire, was born at Holbech in 1687, and educated in Bennet college, Cambridge. While an under-graduate, he often indulged a strong propensity to drawing and designing; but made physics his principal study, and first began to practise at Boston in his native country. In 1717 he removed to London, where, on the recommendation of Dr Mead, he was soon after elected a fellow of the Royal Society; he was one of the first who revived that of the antiquarians in 1718, and was their secretary for many years during his residence in town. In 1729 he took holy orders by the encouragement of archbishop Wake; and was soon after presented by lord-chancellor King with the living of All-Saints in Stamford. In 1741 he became one of the founders of the Egyptian society, which brought him acquainted with the benevolent duke of Montague, one of the members; who prevailed on him to leave Stamford, and presented him to the living of St George the Martyr, Queen Square. He died of a stroke of the palsy in 1765. In his physical capacity, his Dissertation on the Spleen was well received; and his *Itinerarium Curiosum*, the first fruit of his juvenile excursions, was a good specimen of what was to be expected from his riper age. His great learning, and profound researches into the dark remains of antiquity, enabled him to publish many elaborate and curious works: his friends used to call him the *arch-druid* of his age. His discourses, intitled *Palaographia Sacra*, on the vegetable creation, bespeak him a botanist, philosopher, and divine.

STUM, in the wine-trade, denotes the unfermented juice of the grape after it has been several times racked off and separated from its sediment. The casks are for this purpose well matched or fumigated with brimstone every time, to prevent the liquor from fermenting, as it would otherwise readily do, and become wine. See **MUST**.

STUPIDITY. The Greek word *μωροτης* corresponds most with our English word *stupidity* or *foolishness*, when used to express that state of mind in which the intellects are defective. The immediate causes are said to be, a deficiency of vital heat, or a defect in the brain. Stupid children sometimes become sprightly youths; but if stupidity continues to the age of puberty, it is hardly ever removed. If stupidity follows upon a violent passion, an injury done to the head, or other evident cause, and if it continues long, it becomes incurable. But the stupidity which consists in a loss of memory, and succeeds a lethargy, spontaneously ceases when the lethargy is cured.

STUPOR, a numbness in any part of the body, whether occasioned by ligatures obstructing the blood's motion, by the palsy, or the like.

STUPPA, or **STUPE**, in medicine, is a piece of cloth dipped in some proper liquor, and applied to an affected part.

STURDY, a distemper to which cattle are subject, called also the *turning evil*. See **FARRIERY**.

STURGEON. See **ACCIPENSER**.

STURMIUS (John), a learned philologist and rhetorician, was born at Sleida in Eifel near Cologne in 1507. He studied at first in his native country with the sons of count

de Manderscheid, whose receiver his father was. He afterwards pursued his study at Liege in the college of St Jerom, and then went to Louvain in 1524. Five years he spent there, three in learning and two in teaching. He set up a printing-press with Rudger Rescius professor of the Greek tongue, and printed several Greek authors. He went to Paris in 1529, where he was highly esteemed, and read public lectures on the Greek and Latin writers, and on logic. He married there, and kept a great number of boarders; but as he liked what were called the *new opinions*, he was more than once in danger; and this undoubtedly was the reason why he removed to Strasburg in 1537, in order to take possession of the place offered him by the magistrates. The year following he opened a school, which became famous, and by his means obtained of Maximilian II. the title of an university in 1566. He was very well skilled in polite literature, wrote Latin with great purity, and was a good teacher. His talents were not confined to the school; for he was frequently intrusted with deputations in Germany and foreign countries, and discharged these employments with great honour and diligence. He showed extreme charity to the refugees on account of religion: He not only laboured to assist them by his advice and recommendations; but he even impoverished himself for them. He died in his 82d year, after he had been for some time blind. He published many books; the principal of which are, 1. *Partitiones Dialecticae*. 2. *De Educatione Principum*. 3. *De Nobilitate Anglicana*. 4. *Linguae Latinae resolvenda Ratio*. 5. Excellent Notes on Aristotle's and Hermogenes's Rhetoric, &c.

He ought not to be confounded with *John Sturmius*, a native of Mechlin, and physician and professor of mathematics at Louvain, who also wrote several works.

STURNUS, the **STARLING**; a genus of birds belonging to the order of *passeres*. The beak is subulated, depressed, and somewhat blunt; the superior mandible is entire, and somewhat open at the edges; the nostrils are marginated above; and the tongue is sharp and emarginated. There are 15 species according to Dr Latham; the *vulgaris*, *capensis*, *ludovicianus*, *militaris*, *cellaris*, *carunculatus*, *gallinaceus*, *sericeus*, *viridis*, *olivaceus*, *moritanicus*, *loyca*, *dauricus*, *junceti*, and *mexicanus*.

The *vulgaris*, or common starling, is the only species of the *sturnus* that is indigenous. The weight of the male of this species is about three ounces; that of the female rather less. The length is eight inches three quarters: the bill is brown or yellow, but in old birds generally yellow. The whole plumage is black, very resplendent, with characters of blue, purple, and copper: each feather marked with a pale yellow spot. The lesser coverts are edged with yellow, and slightly glossed with green. The quill-feathers and tail dusky: the former edged with yellow on the exterior side; the last with dirty white. The legs of a reddish brown.

The star breeds in hollow trees, eaves of houses, towers, ruins, cliffs, and often in high rocks over the sea, such as that of the isle of Wight. It lays four or five eggs, of a pale-greenish ash-colour; and makes its nest of straw, small fibres of roots, and the like. In winter, stars assemble in vast flocks: they collect in myriads in the fens of Lincolnshire, and do great damage to the fen-men, by roosting on the reeds, and breaking them down by their weight; for reeds are the thatch of the country, and are laid up in harvest with great care. These birds feed on worms and insects; and it is said that they will get into pigeon-houses, for the sake of sucking the eggs. Their flesh is so bitter as to be scarce eatable. They are fond of following oxen and other large cattle as they feed in the meadows, attracted, it is said, by the insects which flutter round them, or by those, perhaps, which

Latham's
Synopsis
vol. iii.

eye,
style.

Buffon's
Nat. Hi-
story of
Birds,
vol. iii.

which swarm in their dung, or in meadows in general. From this habit is derived the German name *Rinder Staren*. They are also accused of feeding on the carcases that are exposed on gibbets; but it is probably in search only of insects. They live seven or eight years, or even longer, in the domestic state. The wild ones cannot be decoyed by the call, because they regard not the scream of the owl. A method has been discovered of taking entire families, by fixing to the walls and the trees where they lodge pots of earthen ware of a convenient form, which the birds often prefer to place their nests in. Many are also caught by the gin and draw-net. In some parts of Italy it is common to employ tame weasels to drag them out of their nests, or rather their holes; for the artifice of man consists in employing one enslaved race to extend his dominion over the rest.

The stare, it is said, can be taught to speak either French, German, Latin, Greek, &c. and to pronounce phrases of some length. Its pliant throat accommodates itself to every inflection and every accent. It can readily articulate the letter R, and acquires a sort of warbling which is much superior to its native song. This bird is spread through an extensive range in the ancient continent. It is found in Sweden, Germany, France, Italy, the Isle of Malta, the Cape of Good Hope, and is everywhere nearly the same; whereas those American birds which have been called stares, present a great diversity of appearance.

STYLE, or STYTHER, in the eye. See CRITHE.

STYLE, a word of various significations, originally deduced from *stylos*, a kind of bodkin wherewith the ancients wrote on plates of lead, or on wax, &c. and which is still used to write on ivory-leaves and paper prepared for that purpose, &c.

STYLE, in dialling, denotes the gnomon or cock of a dial raised on the plane thereof to project a shadow.

STYLE, in botany. See BOTANY, Sect. iv. p. 434.

STYLE, in language, is the peculiar manner in which a man expresses his conceptions. It is a picture of the ideas which rise in his mind, and of the order in which they are there produced.

The qualities of a good style may be ranked under two heads; perspicuity and ornament. It will readily be admitted, that perspicuity ought to be essentially connected with every kind of writing; and to attain it, attention must be paid, first to single words and phrases, and then to the construction of sentences. When considered with respect to words and phrases, it requires these three qualities; purity, propriety, and precision. When considered with regard to sentences, it requires a clear arrangement of the words and unity in the sense; to which, if strength and harmony be added, the style will become ornamented.

One of the most important directions to be observed by him who wishes to form a good style, is to acquire clear and precise ideas on the subject concerning which he is to write or speak. To this must be added frequency of composition, and an acquaintance with the style of the best authors. A servile imitation, however, of any author is carefully to be avoided; for he who copies, can hardly avoid copying faults as well as beauties. A style cannot be proper unless it be adapted to the subject, and likewise to the capacity of our hearers, if we are to speak in public. A simple, clear, and unadorned style, such as that of Swift, is fittest for intricate disquisition; a style elegant as Addison's, or impetuous like Johnson's, is most proper for fixing the attention on truths, which, though known, are too much neglected. We must not be inattentive to the ornaments of style, if we wish that our labours should be read and admired: but he is a contemptible writer, who looks not

beyond the dress of language, who lays not the chief stress upon his matter, and who does not regard ornament as a secondary and inferior recommendation. For further observations on the different kinds of style, see ORATORY, n° 99, &c.

STYLE, in jurisprudence, the particular form or manner of proceeding in each court of jurisdiction, agreeable to the rules and orders established therein: thus we say, the style of the court of Rome, of chancery, of parliament, of the privy-council, &c.

STYLE, in music, denotes a peculiar manner of singing, playing, or composing; being properly the manner that each person has of playing, singing, or teaching; which is very different both in respect of different geniuses, of countries, nations, and of the different matters, places, times, subjects, passions, expressions, &c. Thus we say, the style of Palestrina, of Lully, of Corelli, of Handel, &c.; the style of the Italians, French, Spaniards, &c.

Old STYLE, the Julian method of computing time, as the

New STYLE is the Gregorian method of computation. See KALENDAR.

STYLEPHORUS CHORDATUS, a genus of fishes belonging to the order of *apodes*. This very curious genus was discovered by Dr Shaw, who read a description of it before the Linnæan Society in the year 1788. The eyes are fixed on cylindrical pillars which lie close together. The rostrum, or narrow part which is terminated by the mouth, is connected to the back part of the head by a flexible leathery duplicature, which permits it either to be extended in such a manner that the mouth points directly upwards, or to fall back so as to be received into a sort of case, formed by the upper part of the head. There are three pairs of branchiæ situate under the throat. The pectoral fins are small; the dorsal fin runs from the head to within about an inch and a half of the tail; the caudal fin is short, and is furnished with five remarkable spines. The body is extremely long, and compressed very much, and gradually diminishes as it approaches the tail, which terminates in a process or sting of an enormous length, and finishes in a very fine point. This string, or caudal process, seems to be strengthened throughout its whole length, or at least as far as the eye can trace it, by a sort of double fibre or internal part. The stylephorus chordatus is a native of the West Indian Sea. It was taken between the islands of Cuba and Martinico, near a small cluster of little islands about nine leagues from shore, and was seen swimming near the surface. The whole length of this uncommon animal from the head to the extremity of the caudal process is about thirty-two inches, of which the process itself measures twenty-two.

STYLET, a small dangerous kind of poniard which may be concealed in the hand, chiefly used in treacherous assassinations. The blade is usually triangular, and so small that the wound it makes is almost imperceptible.

STYLITES, PILLAR SAINTS, in ecclesiastical history, an appellation given to a kind of solitaries, who stood motionless upon the tops of pillars, raised for this exercise of their patience, and remained there for several years, amidst the admiration and applause of the stupid populace. Of these we find several mentioned in ancient writers, and even as low as the twelfth century, when they were totally suppressed.

The founder of the order was St Simeon Stylites, a famous anchorite in the fifth century, who first took up his abode on a column six cubits high; then on a second of twelve cubits, a third of twenty-two, a fourth of thirty-six, and on another of forty cubits, where he thus passed thirty-seven years of his life. The tops of these columns were only three feet in diameter, and were defended by a rail that reached almost to the girdle, somewhat resembling a pulpit.

Style

Stylites.

Plate

CCCCXXXV.

Transactions of the
Linnæan Society, vol. ii.

Stylocera- pulpit. There was no lying down in it. The faquirs, or
loides devout people of the East, imitate this extraordinary kind of
Styrax. life to this day.

STYLOCERALOIDES,

STYLO GLOSSUS,

STYLO-HYOIDEUS,

STYLO-PHARYNGEUS,

STYLOIDES,

The names of different
 muscles in the human
 body. See Table of the
 Muscles under ANATOMY.

STYLOSANTHES, in botany: A genus of the *decandria* order, belonging to the *diadelphia* class of plants; and in the natural method ranking under the 32d order, *Papilionaceae*. The calyx is tubulated, very long, having the corolla attached to it. The legumen or pod biarticulated and hooked. Of this there are two species, both natives of Jamaica, viz. 1. *Procumbens*, the *bedysarum procumbens* of Linnæus; a figure of which may be seen in Sloane's Natural History of Jamaica. 2. *Viscosa*, the *trifolium* 2. of Browne; a figure of which is also given by Sloane.

STYPTIC, in pharmacy, a medicine which by its astringency stops hæmorrhagies, &c. See PHARMACY, n° 547.

STYRAX, the STORAX-TREE, in botany: A genus of plants belonging to the class of *decandria*, and to the order of *monogynia*; and in the natural system ranging under the 18th order, *bicornes*. Linnæus only mentions one species of this genus, the *styrax-officinale*; but Aiton, in his *Hortus Kewensis*, has added two more; namely, the *grande folium* and *lavigatum*; and we believe a fourth may now be added, the *styrax benzoin*.

The *officinale* usually rises above twenty feet in height; it sends off many strong branches, which are covered with a roughish bark of a grey colour: the leaves are broad, elliptical, entire, somewhat pointed, on the upper surface smooth, and of a light green colour, on the under surface covered with a whitish down; they are placed alternately, and stand upon short footstalks: the flowers are large, white, and disposed in clusters upon short peduncles, which terminate the branches: the corolla is monopetalous, funnel-shaped, and divided at the limb into five lance-shaped segments: the filaments are ten, placed in a regular circle, and seem to adhere towards the base: the antheræ are erect and oblong: the germen is oval, and supports a slender style, with a simple stigma: the fruit is a pulpy pericarpium, which contains one or two nuts of an oval compressed figure.

The resinous drug called *storax* issues in a fluid state from incisions made in the trunk or branches of the tree. Two sorts of this resin have been commonly distinguished in the shops. 1. *Storax in the tear*: is scarcely, if ever, found in separate tears, but in masses, sometimes composed of whitish and pale reddish brown tears, and sometimes of an uniform reddish yellow or brownish appearance; unctuous and soft like wax, and free from visible impurities. This is supposed to be the sort which the ancients received from Pamphylia in reeds or canes, and which was thence named *calamita*.

2. *Common storax*: in large masses, considerably lighter and less compact than the former, and having a large admixture of woody matter like saw-dust. This appears to be the kind intended by the London college, as they direct their *styrax calamita* to be purified, for medicinal use, by softening it with boiling water, and pressing it out from the feces betwixt warm iron plates; a process which the first sort does not stand in need of. And indeed there is rarely any other than this impure storax to be met with in the shops.

Storax, with some of the ancients, was a familiar remedy as a resolvent, and particularly used in catarrhal complaints, coughs, asthma, menstrual obstructions, &c. and from its

affinity to the balsams it was also prescribed in ulcerations of the lungs, and other states of pulmonary consumption. And our pharmacopœias formerly directed the *pilula e styrace*; but this odoriferous drug has now no place in any of the officinal compounds; and though a medicine which might seem to promise some efficacy in nervous debilities, yet by modern practitioners it is almost totally disregarded.

The *styrax benzoin* is described by Dr Dryander in the Philosophical Transactions for 1787, p. 308, &c. It has been characterized by oblong acuminate leaves, which are downy underneath, and nearly of the length of the racemi. The botanical character of this tree was mistaken by modern botanists till Dr Dryander ascertained it to be a *styrax*. Benzoin was long supposed to be the produce of a species of *laurus*. Linnæus detected this error: but he committed another; for he tells us, that it is furnished by a shrub which, in the country where it grows, is called *croton bezoe*; and afterwards, in his *Supplementum Plantarum*, describes the same plant a second time, under the name of *terminalia benzoin*.

This tree, which is a native of Sumatra, is deemed in six years of sufficient age for affording the benzoin, or when its trunk acquires about seven or eight inches in diameter; the bark is then cut through longitudinally, or somewhat obliquely, at the origin of the principal lower branches, from which the drug exudes in a liquid state, and by exposure to the sun and air soon concretes, when it is scraped off from the bark with a knife or chisel. The quantity of benzoin which one tree affords never exceeds three pounds, nor are the trees found to sustain the effects of these annual incisions longer than ten or twelve years. The benzoin which issues first from the wounded bark is the purest, being soft, extremely fragrant, and very white; that which is less esteemed is of a brownish colour, very hard, and mixed with various impurities, which it acquires during its long continuance upon the trees. Eschelskron distinguishes benzoin into three kinds, viz. *camayan poeti*, or white benjamin, which, upon being melted in a bladder by the heat of the sun, appears marked with red streaks or veins. *Camayan bamatta* is less white than the former, and often spotted with white circles, called eyes, from the number of which its goodness is estimated: it likewise melts by the heat of the sun. *Camayan itam*, or black benjamin, which requires to be melted in hot water for its preservation in bladders. In Arabia, Persia, and other parts of the East, the coarser kinds of benjamin are consumed for fumigating and perfuming the temples, and for destroying insects.

The benzoin which we find here in the shops is in large brittle masses, composed partly of white, partly of yellowish or light brown, and often also of darker coloured pieces: that which is clearest, and contains the most white matter, called by authors *benzoe amygdaloides*, is accounted the best. This resin has very little taste, impressing on the palate only a slight sweetness: its smell, especially when rubbed or heated, is extremely fragrant and agreeable. It totally dissolves in rectified spirit, (the impurities excepted, which are generally in a very small quantity), into a deep yellowish red liquor, and in this state discovers a degree of warmth and pungency, as well as sweetness. It imparts, by digestion, to water also a considerable share of its fragrance, and a slight pungency: the filtered liquor, gently exhaled, leaves not a resinous or mucilaginous extract, but a crystalline matter, seemingly of a saline nature, amounting to one-tenth or one eighth of the weight of the benzoin. Exposed to the fire in proper vessels, it yields a quantity of a white saline concrete, called *flores benzoës*, of an acidulous taste and grateful odour, soluble in rectified spirit, and in water by the assistance of heat.

Woodville's
 Medical
 Botany,
 vol. ii.

Lewis's
 Materia
 Medica,
 vol. ii.

Woodville's
 Medical Be-
 tany, vol. ii.

Styrax,
Styx.

The principal use of this fragrant resin is in perfumes, and as a cosmetic; for which last purpose, a solution of it in spirit of wine is mixed with so much water as is sufficient to render it milky, as twenty times its quantity or more. It promises, however, to be applicable to other uses, and to approach in virtue, as in fragrance, to storax and balsam of Tolu. It is said to be of great service in disorders of the breast, for resolving obstructions of the pulmonary vessels, and promoting expectoration: in which intentions the flowers are sometimes given, from three or four grains to fifteen. The white powder, precipitated by water from solutions of the benzoin in spirit, has been employed by some as similar and superior to the flowers, but appears to be little other than the pure benzoin in substance: it is not the saline, but the resinous matter of the benzoin, that is most disposed to be precipitated from spirit by water. The flowers, snuffed up the nose, are said to be a powerful er-rhine.

Liquid storax is a resinous juice obtained from a tree called by Linnæus *liquidambar styraciflua*, a native of Virginia and Mexico, and lately naturalized in this country. The juice called liquidambar is said to exude from incisions made in the trunk of this tree, and the liquid storax to be obtained by boiling the bark or branches in water. Two sorts of liquid storax are distinguished by authors: one, the purer part of the resinous matter that rises to the surface in boiling, separated by a strainer, of the consistence of honey, tenacious like turpentine, of a reddish or ash brown colour, moderately transparent, of an acrid unctuous taste, and a fragrant smell, faintly resembling that of the solid storax, but somewhat disagreeable: the other, the more impure part, which remains on the strainer, is not transparent, in smell and taste is much weaker, and contains a considerable proportion of the substance of the bark. What is most commonly met with under this name in the shops is of a weak smell and a grey colour, and is supposed to be an artificial composition.

Liquid storax has been employed chiefly in external applications. Among us, it is at present almost wholly in disuse.

STYX (fab. hist.), a celebrated river of hell, round which it flows nine times. The gods held the waters of the Styx in such veneration, that to swear by them was reckoned an oath altogether inviolable. If any of the gods had perjured themselves, Jupiter obliged them to drink the waters of the Styx, which lulled them for one whole year into a senseless stupidity, for the nine following years they were deprived of the ambrosia and the nectar of the gods, and after the expiration of the years of their punishment, they were restored to the assembly of the deities, and to all their original privileges. It is said that this veneration was shown to the Styx, because it received its name from the nymph Styx, who with her three daughters assisted Jupiter in his war against the Titans.

Styx was a river which it was necessary for departed shades to pass before they could enter the infernal regions; and it was the office of Charon to ferry them over in a boat which was kept for that purpose. The ghosts of those who had not been honoured with the rites of sepulture were obliged to wander an hundred years before Charon could admit them into his boat to convey them before the judges of Hades. What could have given rise to this fable of Charon and his boat, it is not very material to inquire. Mythological writers have said, that the Greeks learned it from the Egyptians, which is indeed probable enough; that the Egyptians framed both this, and some other fables relating to the dead, from certain customs peculiar to their country; that in particular there was, not far from Memphis, a famous burying-place, to which the dead bodies

were conveyed in a boat across the lake Acherusia; and that Charon was a boatman who had long officiated in that service. The learned Dr Blackwell says, in his life of Homer, that, in the old Egyptian language, *Charon* signified "ferryman."

SUABIA, a circle of Germany, bounded on the north by the circle of Franconia and that of the Lower Rhine; on the west by the circle of the Lower Rhine and Alsace; on the south by Switzerland; and on the east by the circle of Bavaria. Of all the circles of the empire, Suabia is the most divided; it contains four ecclesiastic and thirteen lay principalities, nineteen independent prelates and abbey, twenty-six earldoms and lordships, and thirty-one free cities. The prime directors of the circle, as they are termed, are the bishop of Constance and the duke of Wirtemberg. The duke has the sole direction of all that relates to war.

The mixture of the various forms of government and religious sects; the oppression exercised by the great on the poor; the game constantly played by the emperor, who possesses many pieces of detached country in Suabia, which depend not on the circle, and can, in consequence of his privileges as archduke of Austria, extend his possessions in it by various ways; are circumstances (says baron Riefbeck) which give the cultivation of the country, and the character of the inhabitants, a most extraordinary cast. In several of the post towns where you stop, you see the highest degree of cultivation in the midst of the most savage wildness; a great degree of knowledge and polish of manners, mixed with the grossest ignorance and superstition; traces of liberty, under the deepest oppression; national pride, together with the contempt and neglect of the native country; in short, all the social qualities in striking contrast and opposition to each other. Those parts of Suabia which belong to the great potentates, such as Wirtemberg, Austria, and Baden, are certainly the most improved. The whole of Suabia may comprehend about nine hundred German square miles, and two millions of people. More than half of these are subjects of the three above mentioned princes, though they are not proprietors of near one half of the lands.

SUARES (Francis), a Jesuit, was born in Granada on the 5th of January 1548. He was a professor of theology at Alcalá, Salamanca, Rome, and Coimbra in Portugal. He died at Lisbon in 1617 with the greatest resignation; "I never thought (said he) that it was so easy to die." His memory was astonishing, he could repeat the whole of his voluminous works by heart. His writings fill 23 folio volumes, and are mostly on theological and moral subjects. His Treatise of Laws has been reprinted in this country. His Defence of the Catholic Faith against the Errors of England was written at the request of pope Paul V. This book was publicly burnt at London by order of James I. When Suarez heard it, he is said to have exclaimed, "O that I too could seal with my blood the truths which I have defended with my pen!"

SUBAH, the general name of the viceroyships, or greater governments, into which the Mogul empire was divided, consisting of several provinces. The jurisdiction of a subahdar, the same as subahship, subadaree, or nizamat.

SUBAHDAR, the viceroy, lord-lieutenant, or governor, holding a subah; the same as nabob or nazim. Also the black commander of a company of Seapoys.

SUBALTERN, a subordinate officer, or one who discharges his post under the command and subject to the direction of another; such are lieutenants, sub-lieutenants, cornets, and ensigns, who serve under the captain.

SUBCLAVIAN, in anatomy, is applied to any thing under the arm-pit or shoulder, whether artery, nerve, vein, or muscle.

Suabia
||
Subclavian.

Baron
Riefbeck's
Travels
through
Germany,
vol. i.

Trans. of
the R. So-
ciety of E-
dinburgh,
vol. ii.

Sub-deacon

Submulti-
ple

SUB-DEACON, an inferior minister, who anciently attended at the altar, prepared the sacred vessels, delivered them to the deacons in time of divine service, attended the doors of the church during communion-service, went on the the bishop's embassies with his letters or messages to foreign churches, and was invested with the first of the holy orders. They were so subordinate to the superior rulers of the church, that, by a canon of the council of Laodicea, they were forbidden to sit in the presence of a deacon without his leave. According to the canons, a person must be twenty-two years of age to be promoted to the order of subdeacon. See **DEACON**.

SUBDOMINANT, in music, a name given by M. Rameau to the fourth note of the tone, which of consequence is the same interval from the tonic when descending as the dominant in rising. This denomination arises from the affinity which this author finds by inversion between the minor mode of the subdominant and the major mode of the tonic.

SUBDUPLICATE RATIO, is when any number or quantity is contained in another twice. Thus 3 is said to be subduple of 6, as 6 is duple of 3. See **RATIO**.

SUBDUPLICATE RATIO of any two quantities, is the ratio of their square roots.

SUBER, the CORK-TREE, in botany. See **QUERCUS**.

SUBJECT, a person under the rule and dominion of a sovereign prince or state.

SUBJECT is also used for the matter of an art or science, or that which it considers, or whereon it is employed: thus the human body is the subject of medicine.

SUBINFEUDATION, was where the inferior lords, in imitation of their superiors, began to carve out and grant to others minuter estates than their own, to be held of themselves; and were so proceeding downwards in *infinitum*, till the superior lords observed, that by this method of subinfeudation they lost all their feudal profits, of wardships, marriages, and escheats, which fell into the hands of these mesne or middle lords, who were the immediate superiors of the terre-tenant, or him who occupied the land. This occasioned the stat. of Westm. 3. or *quia emptores*, 18 Edw. I. to be made; which directs, that, upon all sales or feoffments of lands, the feoffee shall hold the same, not of his immediate feoffer, but of the chief lord of the fee of whom such feoffer himself held it. And from hence it is held, that all manors existing at this day must have existed by immemorial prescription; or at least ever since the 18 Edw. I. when the statute of *quia emptores* was made.

SUBITO, in the Italian music, is used to signify that a thing is to be performed quickly and hastily: thus we meet with *volti subito*, turn over the leaf quickly.

SUBJUNCTIVE, in grammar. See **GRAMMAR**.

SUBLIMATE, a chemical preparation, consisting of quicksilver united with the marine acid. See **CHEMISTRY-Index**.

SUBLIMATION, in chemistry, the condensing and collecting, in a solid form, by means of vessels aptly constructed, the fumes of bodies raised from them by the application of a proper heat. See **CHEMISTRY**, n° 581.

SUBLIME, or **SUBLIMITY**. See the article **GRANDEUR** and **SUBLIMITY**.

SUBLINGUAL ARTERY. See **ANATOMY**.

SUBLINGUAL Glands, in anatomy, two glands under the tongue, placed one on each side thereof.

SUBMULTIPLE, in geometry, &c. A submultiple number, or quantity, is that which is contained a certain number of times in another, and which, therefore, repeated a certain number of times, becomes exactly equal thereto.

Thus 3 is a submultiple of 21. In which sense a submultiple coincides with an aliquot part.

SUBMULTIPLE Ratio, is that between the quantity contained and the quantity containing. Thus the ratio of 3 to 21 is submultiple. In both cases submultiple is the reverse of multiple: 21, *e. gr.* being a multiple of 3, and the ratio of 21 to 3 a multiple ratio.

SUBORDINARIES. See **HERALDRY**, Chap. III. Sect. II. page 454.

SUBORDINATION, a relative term, expressing an inferiority betwixt one person and another.

SUBORNATION, in law, a secret, underhand, preparing, instructing, or bringing in a false witness; and from hence *subornation of perjury* is the preparing or corrupt alluring to perjury. The punishment for this crime was formerly death, then banishment or cutting out the tongue, afterwards forfeiture of goods; and it is now a fine and imprisonment, and never more to be received as evidence. The statute 2 Geo. II. c. 25. superadded a power for the court to order the offender to be sent to the house of correction for a term not exceeding seven years, or be transported for the same period.

SUBPŒNA, in law, a writ whereby common persons are called into chancery, in such cases where the common law hath provided no ordinary remedy; and the name of it proceeds from the words therein, which charge the party called to appear at the day and place assigned, *sub pœna centum librarum*, &c. The subpœna is the leading process in the courts of equity; and by statute, when a bill is filed against any person, process of subpœna shall be taken out to oblige the defendant to appear and answer the bill, &c.

SUBPŒNA ad testificandum, a writ or process to bring in witnesses to give their testimony. If a witness on being served with this process does not appear, the court will issue an attachment against him; or a party, plaintiff or defendant, injured by his non-attendance, may maintain an action against the witness. See *Blackst. Com.* Vol. III. p. 369.

SUBPŒNA in Equity, a process in equity, calling on a defendant to appear and answer to the complainant's bill. See statute 5th Geo. II. c. 25. which enacts, that where the party cannot be found to be served with a subpœna, and absconds (as believed) to avoid being served, a day shall be appointed him to appear to the bill of the plaintiff; which is to be inserted in the London Gazette, read in the parish-church where the defendant last lived, and fixed up at the Royal Exchange; and if the defendant doth not appear upon that day, the bill shall be taken *pro confesso*.

SUBREPTITIOUS, a term applied to a letter, licence, patent, or other act, fraudulently obtained of a superior, by concealing some truth which, had it been known, would have prevented the concession or grant.

SUBROGATION, or **SURROGATION**, in the Civil Law, the act of substituting a person in the place, and intitling him to the rights, of another. In its general sense, subrogation implies a succession of any kind, whether of a person to a person, or of a person to a thing.

There are two kinds of subrogation: the one *conventional*, the other *legal*. *Conventional* subrogation is a contract whereby a creditor transfers his debt, with all appurtenances thereof, to the profit of a third person. *Legal* subrogation is that which the law makes in favour of a person who discharges an antecedent creditor; in which case there is a legal translation of all rights of the ancient creditor to the person of the new one.

SUBSCRIPTION, in general, signifies the signature put at the bottom of a letter, writing, or instrument.

In commerce, it is used for the share or interest which particular persons take in a public stock or a trading company.

*Blackstone's
Common-
law, vol. ii.*

Submulti-
ple
Subscription.

Subscription, by writing their names, and the shares they require, in the books or register thereof.

Subularia. **SUBSCRIPTION** to articles of faith is required of the clergy of every established church, and of some churches not established. Whether such subscription serves any good purpose, in a religious or theological view, is a very doubtful question. It may be necessary in an establishment, as a test of loyalty to the prince, and of attachment to the constitution, civil and ecclesiastical, but it cannot produce uniformity of opinion. As all language is more or less ambiguous, it becomes difficult, if not impossible, to determine in what sense the words of long established creeds are to be interpreted; and we believe that the clergy of the churches of England and Scotland seldom consider themselves as fettered by the Thirty-nine Articles, or the Confession of Faith, when composing instructions either for their respective parishes or for the public at large. See **INDEPENDENTS**.

SUBSCRIPTION, in the commerce of books, signifies an engagement to take a certain number of copies of a book intended to be printed, and a reciprocal obligation of the bookseller or publisher to deliver the said copies, on certain terms.—These subscriptions, which had their rise in England about the middle of the last century, were lately very frequent in France and Holland, and are now very common among ourselves.

SUBSEQUENT, something that comes after another, particularly with regard to the order of time.

SUBSIDY, in law, signifies an aid or tax granted to the king by parliament, for the necessary occasions of the kingdom; and is to be levied on every subject of ability, according to the rate or value of his lands or goods: but this word, in some of our statutes, is confounded with that of customs. See **TAX**.

SUBSTANCE, the subject to which we suppose qualities belong. Thus gold is the substance to which the qualities of ductility, yellowness, density, &c. belong. See **METAPHYSICS**, n° 145.

SUBSTANTIAL, in the schools, something belonging to the nature of substance.

SUBSTANTIVE, in grammar. See **GRAMMAR**.

SUBSTITUTE, a person who officiates for another in his absence.

SUBSTITUTION, in the civil law, a disposition of a testament, whereby the testator substitutes one heir for another, who has only the usufruct, and not the property, of the thing left him.

SUBTRACTION, or **SUBTRACTION**, in arithmetic, the second rule, or rather operation, in arithmetic, whereby we deduct a less number from a greater, to learn their precise difference. See **ARITHMETIC** and **ALGEBRA**.

SUBTANGENT OF A CURVE, the line that determines the intersection of a tangent with the axis; or that determines the point wherein the tangent cuts the axis prolonged.

SUBTENSE, formed from *sub* "under," and *tendo* "I stretch," in geometry, a right line which is opposite to an angle, and drawn between the two extremities of the arch which measures that angle.

SUBTERRANEAN, whatever is under ground: thus naturalists speak of subterranean fires, subterranean damps, &c.

SUBTERRANEAN Cavern. See **QUARRIES**.

SUBTILE, in physics, an appellation given to whatever is extremely small, fine, and delicate; such as the animal-spirits, the effluvia of odorous bodies, &c. are supposed to be.

SUBULARIA, **ROUGH-LEAVED ALYSSON**, or **Awl-**

wort, in botany: A genus of plants belonging to the class of *tetradynamia*, and order of *filiculosa*; and in the natural order ranging under the 39th order, *filiquosa*. The filicula is entire and ovate; the valves are ovate, concave, and contrary to the partitions. The style is shorter than the filicula. There is only one species, the *aquatica*, which is a native of Britain. It is about an inch high. The leaves are awl-shaped, and grow in clusters round the root. The stalk is naked, and produces four or five small white flowers growing alternately on short footstalks. It flowers under water, whereas most aquatic plants emerge above water at the time of flowering. The Author of Nature has, however, carefully prevented the tender flower from receiving any injury from the water, by making the petals close, and form themselves into a kind of arch. This plant grows on the borders of the Highland lakes, in Loch Tay, in Scotland, also in Wales and Ireland.

SUBULATED, something shaped like an awl.

SUCCEDANEUM, in pharmacy, denotes a drug substituted in the place of another.

SUCCESSION, in metaphysics, the idea which we get by reflecting on the ideas that follow one another in our mind; and from the succession of ideas we get the idea of time. See **METAPHYSICS**, n° 93. and 209.

SUCCESSION, in law. See **DESCENT**.

SUCCESSION to the Crown. See **HEREDITARY Right**.—From the days of Egbert, the first sole monarch of England, even to the present, the four cardinal maxims mentioned in that article have ever been held constitutional canons of succession. It is true, as Sir William Blackstone observes, this succession, through fraud or force, or sometimes through necessity, when in hostile times the crown descended on a minor or the like, has been very frequently suspended; but has generally at last returned back into the old hereditary channel, though sometimes a very considerable period has intervened. And even in those instances where this succession has been violated, the crown has ever been looked upon as hereditary in the wearer of it. Of which the usurpers themselves were so sensible, that they for the most part endeavoured to vamp up some feeble show of a title by descent, in order to amuse the people, while they gained the possession of the kingdom. And, when possession was once gained, they considered it as the purchase or acquisition of a new estate of inheritance, and transmitted, or endeavoured to transmit it, to their own posterity by a kind of hereditary right of usurpation. (See *Black. Com.* v. i. 197—217.) From the historical view there given, it appears, that the title to the crown is at present hereditary, though not quite so absolutely hereditary as formerly: and the common stock, or ancestor, from whom the descent must be derived, is also different. Formerly, the common stock was King Egbert; then William the Conqueror; afterwards, in James I.'s time, the two common stocks united; and so continued till the vacancy of the throne in 1688: now it is the Princess Sophia, in whom the inheritance was vested by the new king and parliament. Formerly, the descent was absolute, and the crown went to the next heir without any restriction: but now, upon the new settlement, the inheritance is conditional; being limited to such heirs only, of the body of the Princess Sophia, as are Protestant members of the church of England, and are married to none but Protestants.

And in this due medium consists the true constitutional notion of the right of succession to the imperial crown of these kingdoms. The extremes between which it steers are each of them equally destructive of those ends for which societies were formed and are kept on foot. Where the magistrate, upon every succession, is elected by the people, and

Succession
||
Succinum.

may by the express provision of the laws be deposed (if not punished) by his subjects, this may sound like the perfection of liberty, and look well enough when delineated on paper; but in practice will be ever productive of tumult, contention, and anarchy. And, on the other hand, divine indefeasible hereditary right, when coupled with the doctrine of unlimited passive obedience, is surely of all constitutions the most thoroughly slavish and dreadful. But when such an hereditary right as our laws have created and vested in the royal stock, is closely interwoven with those liberties which are equally the inheritance of the subject; this union will form a constitution, in theory the most beautiful of any, in practice the most approved, and, we trust, in duration the most permanent.

In France the succession to the monarchy was limited to heirs male (see *SALIC*); but in Navarre the crown was inherited by the heir of line, whether male or female. The case stands thus: Philip the Fourth, king of France, furnished the Fair, in the year 1285 espoused Jane queen of Navarre in her own right; and as king consort of this latter kingdom added the title of Navarre to his former one of France. Louis X. son and heir of Philip and Jane (surnamed *Hutin*, or the *Boislerous*), succeeded to both crowns. By Margaret his first wife, who had been crowned queen of Navarre, he left one daughter Joan or Jane. His second wife Clementia was pregnant at the time of his decease, and was delivered of a posthumous son, whom most of the French annalists recognize as John I. of France, though he lived no longer than three weeks. On his death the kingdom of France passed to Philip V. (surnamed the *Long*), and that of Navarre (to which the Salic law could by no construction extend) to Joanna the only child and heir of Louis and Margaret. From Joanna, in lineal succession, the kingdom of Navarre passed to Jane d'Albret, mother of Henry IV. of France, and wife of Anthony of Vendôme, who as king consort wore the crown of Navarre. On the accession of Henry to the kingdom of France, the two monarchies were united, and the four succeeding princes assumed the joint titles. But if ever the monarchy be restored in France, Mary, princess royal and daughter of Louis XVI. will have the same right to the throne of NAVARRE that her uncle has to the throne of France; for she is the undoubted heir of line of the great and illustrious Henry IV.

Lavoisier's
Elements of
Chemistry.

SUCCINIC ACID, an acid extracted from amber by sublimation in a gentle heat, and rises in a concrete form into the neck of the subliming vessel. The operation must not be pushed too far, or by too strong a fire, otherwise the oil of the amber rises along with the acid. The salt is dried upon blotting paper, and purified by repeated solution and crystallization.

The acid is soluble in 24 times its weight of cold water, and in a much smaller quantity of hot water. It possesses the qualities of an acid in a very small degree, and only affects the blue vegetable colours very lightly. The affinities of this acid with the salifiable bases were determined by Mr de Morveau, who is the first chemist that has endeavoured to ascertain them.

SUCCINUM, AMBER, in mineralogy, a species of bitumen classed under the inflammable substances. As a full account of this mineral was given under the word *AMBER*, nothing remains but to mention a few things which recent experiments enable us to add. According to Dr Kirwan, 100 grains of amber afford about 72 of petroleum, 4.5 of succinic acid, and a residue of fixed matter and water. Mr Scheele says, that, when distilled, it yields an aqueous acid resembling vinegar in its qualities. This would induce us to believe it to be of vegetable origin. But its origin is a

point not yet ascertained. Its specific gravity is from 1.065 to 1.100, and melts at 550° of Fahrenheit. Wallerius affirms, that mirrors, prisms, &c. may be made of amber.

SUCCORY, in botany. See *CICORIUM*.

SUCCOTH (anc. geog.); a town which lay between the brook Jabbok and the river Jordan, where Jacob fixed his tents. There was another Succoth where the Israelites first encamped after their departure from Rameses towards the Red Sea. Succoth signifies *tents*.

SUCCUBUS, a term used by some writers for a daemon who assumes the shape of a woman, and as such lies with a man; in which sense it stands opposed to *incubus*, which was a daemon in form of a man, that lies with a woman. But the truth is, the succubus is only a species of the nightmare. See *MEDICINE*, n° 329.

SUCCULA, in mechanics, an axis or cylinder, with flaves in it to move it round; but without any tympanum or peritrochium.

SUCCULENT PLANTS, among botanists, such whose leaves are thick and full of juice.

SUCKER, in ichthyology. See *CYCLOPTERUS*.

SUCKERS, in gardening, the same with *OFFSETS*.

SUCKING-FISH. See *ECHENEIS*.

SUCKLING (Sir John), an English poet and dramatic writer, was the son of Sir John Suckling, comptroller of the household to king Charles I. and born at Witham in Essex in 1613. He discovered an uncommon propensity to the acquiring of languages, insomuch that he is reported to have spoken Latin at five years of age, and to have written it at nine. When he was grown up, he travelled; but seems to have affected nothing more than the character of a courtier and fine gentleman; which he so far attained, that he was allowed to have the peculiar happiness of making every thing he did become him. In his travels he made a campaign under the great Gustavus Adolphus; and his loyalty, if not his valour, appeared in the beginning of our civil wars; for, after his return to England, he raised a troop of horse for the king's service entirely at his own charge; and mounted them so completely and richly, that they are said to have cost him 12,000 l. This troop, with Sir John at its head, behaved so ill in the engagement with the Scots, upon the English borders, in 1639, as to occasion the famous lampoon composed by Sir John Mennis; "Sir John he got him an ambling nag," &c. This ballad, which was set to a brisk tune, was much sung by the parliamentarians, and continues to be sung to this day. This disastrous expedition, and the ridicule that attended it, was supposed to have hastened his death; being seized by a fever, of which he died, at 28 years of age. He was a sprightly wit, and an easy versifier, but no great poet. His works, consisting of a few poems, letters, and plays, have nevertheless gone through several editions.

SUCTION, the act of sucking or drawing up a fluid, as air, water, milk, or the like, by means of the mouth and lungs; or, in a similar manner, by artificial means. See *PNEUMATICS* and *HYDROSTATICS*.

SUDATORY, a name given by the ancient Romans to their hot or sweating rooms; sometimes also called *Laconica*.

SUDEROE. See *FERRO-Islands*.

SUDORIFIC, an appellation given to any medicine that causes or promotes sweat.

SUESSIONES, a branch of the Remi, a people of Gallia Belgica (Pliny); called sometimes *Sueffones*, in the lower age *Suessi*; situated between the Remi to the east, the Nervii to the north, the Veromandui to the west, and the Meldæ to the south, in the tract now called *le Soissonois*.—*Sueffiones*, *Sueffones*, and *Sueffonæ*, the name of their city in the

Succory
||
Sueffiones.

Suet. the lower age; thought to have been formerly called *Noviodunum* (Cæsar), is now called *Soissons*.

Suez. SUET, SEVUM, or *Sebum*, in anatomy, the solid fat found in several animals, as sheep, oxen, &c. but not in the human species. See the article FAT.—It is of the sevum that tallow is made.

SUETONIUS TRANQUILLUS (Caius), a famous Latin historian, was born at Rome, and became secretary to the emperor Adrian, about the 118th year of the Christian era; but that post was taken from him three years after, when several persons fell under that prince's displeasure for not showing the empress Sabina all the respect she deserved. During his disgrace he composed many works, which are lost. Those now extant are his History of the XII first Emperors, and a part of his Treatise of the Illustrious Grammarians and Rhetoricians. Pliny the Younger was his intimate friend, and persuaded him to publish his books. His History of the XII Roman Emperors has been much commended by most of our polite scholars. He represents, in a continued series of curious and interesting particulars, without any digressions or reflections, the actions of the emperors, without omitting their vices, which he exposes with all their deformity, and with the same freedom mentions the good qualities of the very same persons; but the horrid dissoluteness and obscene actions he relates of Tiberius, Caligula, Nero, &c. have made some say, that he wrote the lives of the emperors with the same licentiousness with which they lived. The edition of this history procured by Grævius at Utrecht in 1672, with the excellent Commentaries of Torrentius and Casaubon, and the notes of some other learned critics, is much esteemed. Burman also published an edition in two vols. 4to with notes.

SUEVI, the Catti or Chatti of Cæsar (Strabo), placed on the Rhine: the reason of Cæsar's calling them thus does not appear, though considerably distant from the proper Suevi or Alemanni.

SUEVI (Tacitus), a common name of the people situated between the Elbe and the Vistula, distinguished otherwise by particular names; as in Ptolemy, *Suevi Angeli*, *Suevi Sennones*.

SUEVUS (anc. geog.), a river of Germany, thought to be the same with the Viadrus or Oder, emptying itself at three mouths into the Baltic, the middlemost of which is called *Savine* or *Savene*; which last comes nearer the name *Suevus*.

SUEZ, a small sea-port town, situated near the northern extremity of the Red Sea, and about 30 hours journey east from Cairo. The country around it is a sandy plain, without the smallest spot of verdure. The only water which can be drunk is brought from El-Naba, or the spring, at the distance of three hours journey; and it is so brackish, that without a mixture of rum it is insupportable to Europeans. The town itself is a collection of miserable ruins, the khans being the only solid buildings; yet from March till June, the season when the Jidda and Yambo fleet arrives, the town becomes crowded; but after its departure nobody remains except the governor, who is a Mamlouk, 12 or 14 persons who form his household, and the garrison. The fortress is a defenceless heap of ruins, which the Arabs consider as a citadel, because it contains six brass four pounders, and two Greek gunners, who turn their heads aside when they fire. The harbour is a wretched quay, where the smallest boats are unable to reach the shore, except at the highest tides. There, however, the merchandise is embarked, to convey it over the banks of sand to the vessels which anchor in the road. This road, situated a league from the town, is separated from it by a shore which is left dry at low water; it has no works for its defence, so that the ves-

sels which M. Volney tells us he has seen there, to the number of 28 at a time, might be attacked without opposition; for the ships themselves are incapable of resistance, none having any other artillery than four rusty swivels.

Suez has always been, notwithstanding its local disadvantages, a place of great trade, on account of its geographical situation. It was by the gulph of Suez that the commodities of India were formerly conveyed to Europe, till the discovery of the passage by the Cape of Good Hope converted that trade into a new channel. As the isthmus of Suez, which separates the Red Sea from the Mediterranean, is not more than 57 miles, it has been frequently proposed to join these two seas together by a canal. As there are no mountains nor remarkable inequalities of surface, this plan would at first view appear easy to be executed. But though the difference of levels would not prevent a junction, the great difficulty arises from the nature of the corresponding coasts of the Mediterranean and the Red Sea, which are of a low and sandy soil, where the waters form lakes, shoals, and morasses, so that vessels cannot approach within a considerable distance. It will therefore be found scarcely possible to dig a permanent canal amid these shifting sands: not to mention, that the shore is destitute of harbours, which must be entirely the work of art. The country besides has not a drop of fresh water, and to supply the inhabitants, it must be brought as far as from the Nile.

The best and only method therefore of effecting this junction, is that which has been already successfully practised at different times; which is, by making the river itself the medium of communication for which the ground is perfectly well calculated; for Mount Mokattam suddenly terminating in the latitude of Cairo, forms only a low and semicircular mound, round which is a continued plain from the banks of the Nile as far as the point of the Red Sea. The ancients, who early understood the advantage to be derived from this situation, adopted the idea of joining the two seas by a canal connected with the river. Strabo * observes, * *Lib. xviii.* that this was first executed under Sesostris, who reigned about the time of the Trojan war; and this work was so considerable as to occasion it to be remarked, "that it was 100 cubits (or 170 feet) wide, and deep enough for large vessels." After the Greeks conquered the country, it was restored by the Ptolemies, and again renewed by Trajan. In short, even the Arabs themselves followed these examples. "In the time of Omar ebn el-Kattab (says the historian El Makin), the cities of Mecca and Medina suffering from famine, the Calif ordered Amrou governor of Egypt to cut a canal from the Nile to Kolzoum, that the contributions of corn and barley appointed for Arabia might be conveyed that way."

This canal is the same which runs at present to Cairo, and loses itself in the country to the north-east of Berket-el-Hadj, or the Lake of the Pilgrims.

The place on the west coast of the gulph of Suez, where the children of Israel are supposed to have entered it, is called *Badea*, about six miles to the north of Cape Korondel, on the other side of the gulph, as we are informed in a letter from the ingenious Edward Wortley Montague, F. R. S. to Dr Watson, containing an account of his journey from Cairo to the Written Mountains in the desert of Sinai. Opposite to Badea is a strong current which sets to the opposite shore, about south-east, with a whirlpool called *Birque Pharaone*, the well or pool of Pharaoh, being the place where his host is said to have been destroyed. We are told by the same gentleman, that the Egyptian shore from Suez to Badea is so rocky and steep, that there was no entering upon the gulph but at one of these two places.

The

Suez

Suffolk.

The British nation, we believe, never attempted to carry on commerce with any of the ports of the Red Sea beyond Jidda, till, on the suggestion of Mr Bruce, in 1776, some British merchants at Bengal equipped two or three vessels for Suez, laden with piece-goods of Bengal and coast manufactures. The command of the vessels was committed to Captain Greig, a meritorious seaman; and the management of the goods was entrusted to Mr Straw, a gentleman distinguished for his mercantile knowledge. The sale turned out to advantage; but such great expences were incurred in making presents to the bey of Cairo and Suez, as to consume the whole profits gained by the sale of the cargo. The great purpose of the expedition was, however, accomplished, as a firman was obtained from the government of Cairo to trade by the way of Suez. In consequence of this, three ships went to Suez the following year, and as many in 1778. The opening of this trade alarmed the jealousy of the East India Company; they applied to our government, and orders were given to relinquish this promising commerce. These orders reached Egypt sooner than Bengal, and the consequence was fatal to the unfortunate adventurers who visited Suez that year (1779). By a plan concerted between the beys, a large body of Bedouin Arabs attacked the caravan passing from Suez to Cairo with goods valued at 12 lacks of rupees. The goods were plundered, the Europeans were stripped and left naked in the desert, exposed to the burning rays of the sun, without a drop of water to quench their thirst, or food to support life. Most of them died, and some of their bodies were afterwards found mangled and disfigured by wolves. We have been favoured with a particular account of the sufferings of our countrymen by a correspondent, which, we are sorry, we have not room to insert. Those who wish to obtain a more full account may consult the Annual Register for 1781 or 1782.

SUFFETULA (anc. geog.), a town of Africa, in the dominions of Carthage; probably so called from Suffetes, the title of the magistrates of that city. It is now called *Spaitla*, in the kingdom of Tunis, and has many elegant remains of antiquity. There are three temples in a great measure entire; one of them of the Composite order, the other two Corinthian. "A beautiful and perfect capital of the Composite order (says Mr Bruce), the only perfect one that now exists, is designed in all its parts in a very large size; and with the detail of the rest of the ruin, is a precious monument of what that order was, now in the collection of the king." The town itself (he says) is situated in the most beautiful spot in Barbary, surrounded by great numbers of juniper-trees, and watered by a pleasant stream, which sinks under the earth at that place, without appearing any more.

SUFFOCATION, in medicine, the privation of respiration or breathing. See the articles DROWNING, HANGING, &c.

SUFFOLK, a county of England. Its name is contracted from *Southfolk*, so called from its situation in regard to Norfolk. It is bounded on the west by Cambridgeshire; on the south by Essex, from which it is parted by the river Stour; on the east by the German Ocean; and on the north by Norfolk, separated from it by the Lesser Ouse and the Waveney. From west to east it is 52 miles in length, about 20 at a medium in breadth, and 196 in circumference. It contains 22 hundreds, 29 market towns, 575 parishes, upwards of 34,000 houses, and more than 200,000 inhabitants. The whole is divided into two parts, viz. the Liberty of St Edmund, and the Geldable; the former of which contain the west parts of the county, and the other the east; and there is a grand jury for each at the

assizes. The air is reckoned as wholesome and pleasant as any in the kingdom, nor is it otherwise upon the sea coast, which is dry and sandy, and free from salt marshes. The soil, except to the west and upon the sea-coast, is very rich, being a compound of clay and marle. Towards the sea there are large heaths and tracts of sand; but these produce hemp, rye, and pease, and feed great flocks of sheep. About Newmarket the soil is much the same; but in high Suffolk or the woodlands, besides wood, there are very rich pastures, where abundance of cattle are fed. In other parts of the county, as about Bury, there is plenty of corn. As this county is noted for the richness of its pastures, so is it for butter and cheese, especially the former, which is said to be remarkably good; so that being packed up in firkins, it is sold for all uses both by sea and land, and conveyed to many parts of England, especially to London. The inland parts of the county are well supplied with wood for fuel, and those upon the sea-coast with coals from Newcastle. The manufactures of the county are chiefly wool-len and linen cloth. It lies in the diocese of Norwich, has two archdeacons, viz. of Sedbury and Suffolk; gives title of earl to a branch of the Howards; sends two members to parliament for the county, and two for each of the following places, Ipswich, Dunwich, Orford, Aldborough, Sudbury, Eye, and St Edmund's-Bury. The county is extremely well watered by the following rivers, which either traverse its borders, or run across into the German Ocean, viz. the Lesser Ouse, the Waveney, the Blithe, the Deben, the Orwell or Gipping, and the Stour.

SUFFRAGAN, an appellation given to simple bishops with regard to archbishops, on whom they depend, and to whom appeals lie from the bishops courts.

Suffragan is likewise the appellation given to a bishop, who is occasionally appointed to reside in a town or village, and assist the diocesan.

SUFFRAGE, denotes a vote given in an assembly, where something is deliberated on, or where a person is elected to an office or benefice.

SUFFRUTEX, among botanists, denotes an undershrub, or the lowest kind of woody plants, as lavender.

SUGAR, a solid sweet substance obtained from the juice of the sugar-cane; or, according to chemists, an essential salt, capable of crystallization, of a sweet and agreeable flavour, and contained in a greater or less quantity in almost every species of vegetables, but most abundant in the sugar-cane.

As the sugar-cane is the principal production of the West Indies, and the great source of their riches; as it is so important in a commercial view, from the employment which it gives to seamen, and the wealth which it opens for merchants; and besides is now become a necessary of life—it may justly be esteemed one of the most valuable plants in the world. The quantity consumed in Europe is estimated at nine millions Sterling, and the demand would probably be greater if it could be sold at a reduced price. Since sugar then is reckoned so precious a commodity, it must be an object of desire to all persons of curiosity and research, to obtain some general knowledge of the history and nature of the plant by which it is produced, as well as to understand the process by which the juice is extracted and refined. We will therefore first inquire in what countries it originally flourished, and when it was brought into general use, and became an article of commerce.

From the few remains of the Grecian and Roman authors which have survived the ravages of time, we can find no proofs that the juice of the sugar-cane was known at a very early period. There can be no doubt, however, that in those countries where it was indigenous its value was not long con-

Suffragan

Sugar.

¹ **Sugar.** concealed. It is not improbable that it was known to the ancient Jews; for there is some reason to suppose, that the Hebrew word קנה, which occurs frequently in the Old Testament, and is by our translators rendered sometimes *calamus* and sometimes *sweet-cane*, does in fact mean the sugar-cane. The first passage in which we have observed it mentioned is Exod. xxx. 23. where Moses is commanded to make an ointment with myrrh, cinnamon, *kené*, and cassia. Now the *kené* does not appear to have been a native of Egypt nor of Judea; for in Jeremiah vi. 20. it is mentioned as coming from a far country. "To what purpose cometh there to me incense from Sheba and the sweet-cane from a far country?" This is not true of the *calamus aromaticus*, which grows spontaneously in the Levant, as well as in many parts of Europe. If the cinnamon mentioned in the passage of Exodus quoted above was true cinnamon, it must have come from the East Indies, the only country in the world from which cinnamon is obtained. There is no difficulty therefore in supposing, that the sugar-cane was exported from the same country. If any credit be due to etymology, it confirms the opinion that *kené* denotes the sugar-cane; for the Latin word *canna* and the English word *cane* are evidently derived from it. It is also a curious fact, that *sachar* or *sheker* †, in Hebrew, signifies *inebriation*, from which the Greek word σακχαρ "sugar" is undoubtedly to be traced.

The sugar-cane was first made known to the western parts of the world by the conquests of Alexander the Great. ² **Lib. xv.** Strabo * relates that Nearchus his admiral found it in the East Indies in the year before Christ 325. It is evidently alluded to in a fragment of Theophrastus, preserved in Photius. Varro, who lived A. C. 68, describes it in a fragment quoted by Isidorus § as a fluid pressed from reeds of a large size, which was sweeter than honey ||. Dioscorides, about the year 35 before Christ, says "that there is a kind of honey called *saccharon*, which is found in India and Arabia Felix. It has the appearance of salt, and is brittle when chewed. If dissolved in water, it is beneficial to the bowels and stomach, is useful in diseases of the bladder and kidneys, and, when sprinkled on the eye, removes those substances that obscure the sight." This is the first account we have of its medical qualities. Galen often prescribed it as a medicine. Lucan relates, that an oriental nation in alliance with Pompey used the juice of the cane as a common drink.

Quique bibunt tenera dulces ab arundine succos.

Lib. iii. 237.

Pliny says it was produced in Arabia and India, but that the best came from the latter country. It is also mentioned by Arrian, in his *Periplus* of the Red Sea, by the name of Σακχαρ (*sachar*) as an article of commerce from India to the Red Sea. ³ **Nat. Hist.** ⁴ **De Judio** ⁵ **Di.** ⁶ **Lib. ii.** ⁷ **Prob. 79.** ⁸ **Is a native of the East Indies.** ⁹ **That the sugar-cane is an indigenous plant in some parts of the East Indies, we have the strongest reason to believe; for Thunberg found it in Japan, and has accordingly mentioned it as a native of that country in his *Flora Japonica*, published in 1784. Osbeck also found it in China in 1751. It may indeed have been transplanted from some other country; but as it does not appear from history that the inhabitants of Japan or China ever carried on any commerce with remote nations, it could only be conveyed from some neighbouring country. Marco Polo, a noble Venetian, who**

travelled into the East about the year 1250, found sugar in abundance in Bengal. Vasco de Gama, who doubled the Cape of Good Hope in 1497, relates, that a considerable trade in sugar was then carried on in the kingdom of Calicut. On the authority of Dioscorides and Pliny, too, we should be disposed to admit, that it is a native of Arabia, did we not find, on consulting Niebuhr's Travels, that that botanist has omitted it when enumerating the most valuable plants of that country. If it be a spontaneous production of Arabia, it must still flourish in its native soil. Mr Bruce found it in Upper Egypt. If we may believe the relation of Giovan Lioni, a considerable trade was carried on in sugar in Nubia in 1500: it abounded also at Thebes, on the Nile, and in the northern parts of Africa, about the same period.

There is reason to believe that the sugar-cane was introduced into Europe during the crusades; expeditions which however romantic in their plan, and unsuccessful in their execution, were certainly productive of many advantages to the nations of Europe. ⁵ **Introduced into Europe probably during the crusades.** Albertus Aquisensis, a monkish writer, observes, that the Christian soldiers in the Holy Land frequently derived refreshment and support during a scarcity of provisions by sucking the canes. This plant flourished also in the Morea, and in the islands of Rhodes and Malta; from which it was transported into Sicily. The date of this transaction it is not easy to ascertain; but we are sure that sugar was cultivated in that island previous to the year 1166; for Lafitau the Jesuit, who wrote a history of the Portuguese discoveries, mentions a donation made that year to the monastery of St Bennet, by William the second king of Sicily, of a mill for grinding sugar-canes, with all its rights, members, and appurtenances.

From Sicily, where the sugar-cane still flourishes on the sides of mount Hybla, it was conveyed to Spain, Madeira, ⁶ **Supposed by some not a native of America or the West Indies.** the Canary and Cape de Verd islands, soon after they were discovered in the 15th century.

An opinion has prevailed, that the sugar-cane is not a native of the western continent, or its adjacent islands the West Indies, but was conveyed thither by the Spaniards or Portuguese soon after the discovery of America by Columbus. From the testimony of Peter Martyr, in the third book of his first decade, composed during Columbus's second voyage, which commenced in 1493 and ended in 1495, it appears, that the sugar-cane was known at that time in Hispaniola. It may be said, that it was brought thither by Columbus; but for this assertion we have found no direct evidence; and though we had direct evidence, this would not prove that the sugar-cane was not an indigenous plant of the West Indies. There are authors of learning who, after investigating this subject with attention, do not hesitate to maintain, that it is a native both of the islands and of the continent of America.

P. Labat has supported this opinion with much appearance of truth †; and, in particular, he appeals to the testimony of Thomas Gage, an Englishman, who visited New Spain in 1625. Gage enumerates sugar canes among the provisions with which the Charaibes of Guadaloupe supplied his ship. "Now (says Labat) it is a fact that the Spaniards had never cultivated an inch of ground in the Smaller Antilles. Their ships commonly touched at those islands indeed for wood and water; and they left swine in the view of supplying with fresh provisions such of their countrymen as might call there in future; but it would be absurd in the highest

(A) For a more minute account of the history of sugar in the early and middle ages, a paper of the Manchester Transactions, in Volume IV. by Dr Falconer, may be consulted.

Sugar.

highest degree to suppose, that they would plant sugar-canes, and at the same time put hogs ashore to destroy them.

"Neither had the Spaniards any motive for bestowing this plant on islands which they considered as of no kind of importance, except for the purpose that has been mentioned; and to suppose that the Charaibes might have cultivated, after their departure, a production of which they knew nothing, betrays a total ignorance of the Indian disposition and character.

8

From testimony.

"But (continues Labat) we have surer testimony, and such as proves, beyond all contradiction, that the sugar-cane is the natural production of America. For, besides the evidence of Francis Ximenes, who, in a Treatise on American Plants, printed at Mexico, asserts, that the sugar-cane grows without cultivation, and to an extraordinary size, on the banks of the river Plate, we are assured by Jean de Lery, a Protestant minister, who was chaplain in 1556 to the Dutch garrison in the fort of Coligny, on the river Janeiro, that he himself found sugar-canes in great abundance in many places on the banks of that river, and in situations never visited by the Portuguese. Father Hennepin and other voyagers bear testimony in like manner to the growth of the cane near the mouth of the Mississippi; and Jean de Laet to its spontaneous production in the island of St Vincent. It is not for the plant itself, therefore, but for the secret of making sugar from it, that the West Indies are indebted to the Spaniards and Portuguese; and these to the nations of the east."

Such is the reasoning of Labat, which the learned Lafitau has pronounced incontrovertible; and it is greatly strengthened by recent discoveries, the sugar-cane having been found in many of the islands of the Pacific Ocean by our late illustrious navigator Captain Cook.

9

Description of the sugar cane.

The sugar-cane, or *saccharum officinarum* of botanists, is a jointed reed, commonly measuring (the flag part not included) from three feet and a half to seven feet in height, but sometimes rising to 12 feet. When ripe it is of a fine straw colour inclining to yellow, producing leaves or blades, the edges of which are finely and sharply serrated, and terminating in an arrow decorated with a panicle. The joints in one stalk are from 40 to 60 in number, and the stalks rising from one root are sometimes very numerous. The young shoot ascends from the earth like the point of an arrow; the shaft of which soon breaks, and the two first leaves, which had been inclosed within a quadruple sheath of seminal leaves, rise to a considerable height (s). See Plate CCCCLXXXVI. M is the arrow and N the lower part with the root.

10
Soil most favourable to its growth.

As the cane is a rank succulent plant, it must require a strong deep soil to bring it to perfection; perhaps indeed no soil can be too rich for this purpose. The soil which experience has found to be most favourable to the cultivation of it in the West Indies is the dark grey loam of St Christopher's, which is so light and porous as to be penetrable by the slightest application of the hoe. The under stratum is gravel from 8 to 12 inches deep. Canes planted in particular spots in this island have been known to yield 8000

pounds of Muscovado sugar from a single acre. The average produce of the island for a series of years has been 16,000 hogheads of 16 cwt. which is one-half only of the whole cane-land, or 8500 acres. When annually cut, it gives nearly two hogheads of 16 cwt. per acre for the whole of the land in ripe canes.

Next to the ashy loam of St Christopher's is the soil which in Jamaica is called *brick-mold*; not as resembling a brick in colour, but as containing such a due mixture of clay and sand as is supposed to render it well adapted for the use of the kiln. It is a deep, warm, and mellow, hazel earth, easily worked; and though its surface soon grows dry after rain, the under stratum retains a considerable degree of moisture in the driest weather; with this advantage too, that even in the wettest season it seldom requires trenching. Plant canes, by which is meant canes of the first growth, have been known in very fine seasons to yield two tons and a half of sugar per acre. After this may be reckoned the black mold of several varieties. The best is the deep black

earth of Barbadoes, Antigua, and some other of the windward islands; but there is a species of this mold in Jamaica that is but little, if any thing inferior to it, which abounds with limestone and flint on a substratum of soapy marl. Black mold on clay is more common; but as the mold is generally shallow, and the clay stiff and retentive of water, this last sort of land requires great labour, both in ploughing and trenching, to render it profitable. When manured and properly pulverized, it becomes very productive. It is unnecessary to attempt a minute description of all the other soils which are found in these islands. There is, however, a peculiar sort of land on the north side of Jamaica, chiefly in the parish of Trelawney, that cannot be passed over unnoticed, not only on account of its scarcity but its value; few soils producing finer sugars, or such as answer so well in the pan; an expression signifying a greater return of refined sugar than common. The land alluded to is generally of a red colour; the shades of which, however, vary considerably from a deep chocolate to a rich scarlet; in some places it approaches to a bright yellow, but it is everywhere remarkable, when first turned up, for a glossy or shining surface, and if wetted stains the fingers like paint.

As in every climate there is a season more favourable for vegetation than others, it is of great importance that plants for seed be committed to the ground at the commencement of this season. As the cane requires a great deal of moisture to bring it to maturity, the properest season for planting it is in the months of September and October, when the autumnal rains commence, that it may be sufficiently luxuriant to shade the ground before the dry weather sets in. Thus the root is kept moist, and the crop is ripe for the mill in the beginning of the ensuing year. Canes planted in the month of November, or later in the season, lose the advantage of the autumnal rains; and it often happens that dry weather in the beginning of the ensuing year retards their vegetation until the vernal or May rains set in, when they sprout both at the roots and the joints; so that

11
Proper season for planting it.

(s) "A field of canes, when standing, in the month of November, when it is in arrow or full blossom (says Mr Beckford in his descriptive Account of the Island of Jamaica), is one of the most beautiful productions that the pen or pencil can possibly describe. It in common rises from three to eight feet or more in height; a difference of growth that very strongly marks the difference of soil or the varieties of culture. It is when ripe of a bright and golden yellow; and where obvious to the sun, is in many parts very beautifully streaked with red: the top is of a darkish green; but the more dry it becomes, from either an excess of ripeness or a continuance of drought, of a russet yellow, with long and narrow leaves depending; from the centre of which shoots up an arrow like a silver wand from two to six feet in height; and from the summits of which grows out a plume of white feathers, which are delicately fringed with a lilac dye; and indeed is, in its appearance, not much unlike the tuft that adorns this particular and elegant tree."

^{Sugar.} by the time they are cut the field is loaded with unripe suckers instead of sugar-canes. A January plant, however, commonly turns out well; but canes planted very late in the spring, though they have the benefit of the May rains, seldom answer expectation; for they generally come in unseasonably, and throw the ensuing crops out of regular rotation. They are therefore frequently cut before they are ripe; or if the autumnal seasons set in early, are cut in wet weather, which has probably occasioned them to spring afresh; in either case the effect is the same: The juice is unconcocted, and all the sap being in motion, the root is deprived of its natural nourishment, to the great injury of the ratoon. The chief objection to a fall plant is this, that the canes become rank and top heavy, at a period when violent rains and high winds are expected, and are therefore frequently lodged before they are fit to be cut.

¹²
Method of
planting

The sugar-cane is propagated by the top-shoots, which are cut from the tops of the old canes. The usual method of planting in the West Indies is this: The quantity of land intended to be planted, being cleared of weeds and other incumbrances, is first divided into several plats of certain dimensions, commonly from 15 to 20 acres each; the spaces between each plat or division are left wide enough for roads, for the convenience of carting, and are called *intervals*. Each plat is then subdivided, by means of a line and wooden pegs, into small squares of about three feet and a half. Sometimes indeed the squares are a foot larger; but this circumstance makes but little difference. The negroes are then placed in a row in the first line, one to a square, and directed to dig out with their hoes the several squares, commonly to the depth of five or six inches. The mold which is dug up being formed into a bank at the lower side, the excavation or cane-hole seldom exceeds 15 inches in width at the bottom, and two feet and a half at the top. The negroes then fall back to the next line, and proceed as before. Thus the several squares between each line are formed into a trench of much the same dimensions with that which is made by the plough. An able negro will dig from 100 to 120 of these holes for his day's work of ten hours; but if the land has been previously ploughed and lain fallow, the same negro will dig nearly double the number in the same time (c).

¹³
And clean-
ing it.

The cane-holes or trench being now completed, whether by the plough or by the hoe, and the cuttings selected for planting, which are commonly the tops of the canes that have been ground for sugar (each cutting containing five or six gems), two of them are sufficient for a cane hole of the dimensions described. These, being placed longitudinally in the bottom of the hole, are covered with mold about two inches deep; the rest of the bank being intended for future use. In 12 or 14 days the young sprouts begin to appear; and as soon as they rise a few inches above the ground, they are, or ought to be, carefully cleared of weeds, and furnished with an addition of mold from the banks. This is usually performed by the hand. At the end of four or five months the banks are wholly levelled, and the spaces between the rows carefully hoe-ploughed. Frequent cleanings, while the canes are young, are indeed so essentially necessary, that no other merit in an overseer can compensate

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for the want of attention in this particular. A careful manager will remove at the same time all the lateral shoots or suckers that spring up after the canes begin to joint, as they seldom come to maturity, and draw nourishment from the original plants.

¹⁴
The plough might be used with advantage.
“In the cultivation of other lands, in Jamaica especially (says Mr Edwards, the elegant historian of the West Indies, whose superior excellence has induced us frequently to refer to him in the course of this article), the plough has been introduced of late years, and in some few cases to great advantage; but it is not every soil or situation that will admit the use of the plough; some lands being much too stony, and others too steep; and I am sorry I have occasion to remark, that a practice commonly prevails in Jamaica, on properties where this auxiliary is used, which would exhaust the finest lands in the world. It is that of ploughing, then cross-ploughing, round-ridging, and harrowing the same lands from year to year, or at least every other year, without affording manure: accordingly it is found that this method is utterly destructive of the ratoon or second growth, and altogether ruinous. It is indeed astonishing that any planter of common reading or observation should be passive under so pernicious a system. Some gentlemen, however, of late manage better: their practice is to break up stiff and clayey land, by one or two ploughings, early in the spring, and give it a summer's fallow. In the autumn following, being then mellow and more easily worked, it is holed and planted by manual labour after the old method, which has been already described. But in truth, the only advantage-^{Edwards's History of the West Indies, vol. ii.}ous system of ploughing in the West Indies is to confine it to the simple operation of holing, which may certainly be performed with much greater facility and dispatch by the plough than by the hoe; and the relief which, in the case of stiff and dry soils, is thus given to the negroes, exceeds all estimation, in the mind of a humane and provident owner. On this subject I speak from practical knowledge. At a plantation of my own, the greatest part of the land which is annually planted is neatly and sufficiently laid into cane-holes, by the labour of one able man, three boys, and eight oxen, with the common single-wheeled plough. The ploughshare indeed is somewhat wider than usual; but this is the only difference, and the method of ploughing is the simplest possible. By returning the plough back along the furrow, the turf is alternately thrown to the right and to the left, forming a trench seven inches deep, about two feet and a half wide at the top, and one foot wide at the bottom. A space of 18 or 20 inches is left between each trench, on which the mold being thrown by the share, the banks are properly formed, and the holing is complete. Thus the land is not exhausted by being too much exposed to the sun; and in this manner a field of 20 acres is holed with one plough, and with great ease, in 13 days. The plants are afterwards placed in the trench as in the common method, where manual labour alone is employed.

In most parts of the West Indies it is usual to hole and plant a certain proportion of the cane-land, commonly one-third in annual rotation. Canes of the first year's growth¹⁵ are called *plant canes*, as has been already observed. The med ac-^{Canes na-}cording to^{the age of} the roots of the canes that have^{been} their roots.

H

(c) As the negroes work at this business very unequally, according to their different degrees of bodily strength, it is sometimes the practice to put two negroes to a single square; but if the land has not had the previous assistance of the plough, it commonly requires the labour of 50 able negroes for 13 days to hole 20 acres. In Jamaica, some gentlemen, to ease their own slaves, have this laborious part of the planting-business performed by job-work. The usual price for holing and planting is L. 6 currency *per* acre (equal to L. 4, 7 s. Sterling). The cost of falling and clearing heavy woodland is commonly as much more.

¹⁵ **Sugar.** been previously cut for sugar are called *ratoons*; the first yearly returns from their roots are called *first ratoons*; the second year's growth *second ratoons*.

¹⁶ **Manures employed.** Mr Edwards informs us, that the manure generally used is a compost formed, 1st, Of the vegetable ashes, drawn from the fires of the boiling and still houses. 2^{dly}, Feculencies discharged from the still-house, mixed up with rubbish of buildings, white-lime, &c. 3^{dly}, Refuse, or field-trash (*i. e.*), the decayed leaves and stems of the canes; so called in contradistinction to cane-trash, reserved for fuel. 4^{thly}, Dung, obtained from the horse and mule stables, and from moveable pens, or small inclosures made by posts and rails, occasionally shifted upon the lands intended to be planted, and into which the cattle are turned at night. 5^{thly}, Good mold, collected from gullies and other waste places, and thrown into the cattle pens.

¹⁷ **The sugar-cane destroyed by monkeys.** The sugar-cane is liable to be destroyed by monkeys, rats, and insects. The upland plantations suffer greatly from monkeys; these creatures, which now abound in the mountainous parts of St Christopher's, were first brought thither by the French, when they possessed half that island; they come down from the rocks in silent parties by night, and having posted centinels to give the alarm if any thing approaches, they destroy incredible quantities of the cane, by their gambols as well as their greediness. It is in vain to set traps for these creatures, however baited; and the only way to protect the plantation, and destroy them, is to set a numerous watch, well armed with fowling-pieces, and furnished with dogs. The negroes will perform this service cheerfully, for they are very fond of monkeys as food. The celebrated Father Labat says, they are very delicious, but the white inhabitants of St Kitt's never eat them.

¹⁸ **Grainger's History of the Sugar-cane.**

¹⁸ **Rats,**

The low-land plantations suffer as much by rats as those on the mountains do from monkeys; but the rats, no more than the monkeys, are natives of the place; they came with the shipping from Europe, and breed in the ground under loose rocks and bushes: the field negroes eat them greedily, and they are said to be publicly sold in the markets at Jamaica. To free the plantations from these vermin, the breed of wild cats should be encouraged, and snakes suffered to multiply unmolested; they may also be poisoned with arsenic, and the rasped root of the cassava made into pellets, and plentifully scattered over the grounds. This practice, however, is dangerous; for as the rats when thus poisoned become exceeding thirsty, they run in droves to the neighbouring streams, which they poison as they drink, and the cattle grazing on the banks of these polluted waters have frequently perished by drinking after them: It is safer therefore to make the pellets of flour, kneaded with the juice of the night-shade, the scent of which will drive them away though they will not eat it. There is an East Indian animal called *mungoes*, which bears a natural antipathy to rats; if this animal was introduced into our sugar islands, it would probably extirpate the whole race of these noxious vermin. The *formica omnivora* of Linnæus, the carnivorous ant, which is called in Jamaica the *raffle's ant*, would soon clear a sugar plantation of rats.

¹⁹ **Sugar.** The sugar-cane is also subject to a disease which no foresight can obviate, and for which human wisdom has hitherto in vain attempted to find a remedy. This disease is called the *blast*, and is occasioned by the *aphis* of Linnæus. When this happens, the fine, broad, green blades become sickly, dry, and withered; soon after they appear stained in spots; and if these spots are carefully examined, they will be found to contain innumerable eggs of an insect like a bug, which are soon quickened, and cover the plants with the vermin: the juice of the canes thus affected becomes sour, and no future shoot issues from the joints. Ants also concur with the bugs to spoil the plantation, and against these evils it is hard to find a remedy.

²⁰ **Time at which the crops ripen.** The crops of sugar-canes do not ripen precisely at the same period in all the colonies. In the Danish, Spanish, and Dutch settlements, they begin in January, and continue to ripen till October. This method doth not imply any fixed season for the maturity of the sugar-cane. The plant, however, like others, must have its progress; and it hath been justly observed to be in flower in the months of November and December. It must necessarily follow, from the custom these nations have adopted of continuing to gather their crops for 10 months without intermission, that they cut some canes which are not ripe enough, and others that are too ripe, and then the fruit hath not the requisite qualities. The time of gathering them should be at a fixed season, and probably the months of March and April are the fittest for it; because all the sweet fruits are ripe at that time, while the sour ones do not arrive to a state of maturity till the months of July and August.

The English cut their canes in March and April; but they are not induced to do this on account of their ripeness. The drought that prevails in their islands renders the rains which fall in September necessary to their planting; and as the canes are 18 months in growing, this period always brings them to the precise point of maturity (D).

²¹ **A season of festivity.** "The time of crop in the sugar islands (says Mr Edwards) is the season of gladness and festivity to man and beast. So palatable, salutary, and nourishing, is the juice of the cane, that every individual of the animal creation, drinking freely of it, derives health and vigour from its use. The meagre and sickly among the negroes exhibit a surprising alteration in a few weeks after the mill is set in action. The labouring horses, oxen, and mules, though almost constantly at work during this season, yet, being indulged with plenty of the green tops of this noble plant, and some of the scummings from the boiling-house, improve more than at any other period of the year. Even the pigs and poultry fatten on the refuse. In short, on a well-regulated plantation, under a humane and benevolent director, there is such an appearance during crop-time of plenty and busy cheerfulness, as to soften, in a great measure, the hardships of slavery, and induce a spectator to hope, when the miseries of life are represented as insupportable, that they are sometimes exaggerated through the medium of fancy."

The plants being cut, the branches at the top are given to the cattle for food; the top-shoot, which is full of eyes,

(D) The account given in the text concerning the time when the sugar-canes are collected, we have taken from the Abbé Raynal's History of the Trade and Settlements of the East and West Indies; but Mr Cazaud observes, that in February, March, and April, all the canes, whatever be their age, are as ripe as the nature of the soil ever allows them to be. He says farther, that the dryness of the weather, and not the age of the canes, which increases from January to April, is the cause that in January 400 gallons of juice commonly yield 48 gallons of sugar and molasses, one with another; in February from 56 to 64; in March from 64 to 72; in April sometimes 80; after which period the sugar ferments, and even burns, when the refiner is not very expert at his business.

²² Sugar, is preserved for planting. The canes are cut into pieces about a yard long, tied up in bundles, and carried in carts to the mill, where they are bruised, and the juice is extracted from them. The mill consists principally of three upright iron-plated rollers or cylinders, from 30 to 40 inches in length, and from 20 to 25 inches in diameter; and the middle one, to which the moving power is applied, turns the other two by means of cogs. Between these rollers, the canes (being previously cut short, and tied into bundles) are twice compressed; for having passed through the first and second rollers, they are turned round the middle one by a circular piece of frame-work or screen, called in Jamaica the *Dumb-rotturner*, and forced back through the second and third; an operation which squeezes them completely dry, and sometimes even reduces them to powder. The cane juice is received in a leaden bed, and thence conveyed into a vessel called the *receiver*. The refuse, or macerated rind of the cane (which is called *cane-trash*, in contradistinction to *field-trash*), serves for fuel to boil the liquor.

²³ The juice extracted from them. The juice as it flows from the mill, taken at a medium, contains eight parts of pure water, one part of sugar, and one part consisting of coarse oil and mucilaginous gum, with a portion of essential oil.

²⁴ Vessels used for purifying it are, As this juice has a strong disposition to fermentation, it must be boiled as soon as possible. There are some water-mills that will grind with great ease canes sufficient for 30 hogsheds of sugar in a week. It is necessary to have boiling vessels, or clarifiers, that will correspond in dimensions to the quantity of juice flowing from the receiver. These clarifiers are commonly three in number, and are sometimes capable of containing 1000 gallons each; but it is more usual to see them of 300 or 400 gallons each. Besides the clarifiers which are used for the first boiling, there are generally four coppers or boilers. The clarifiers are placed in the middle or at one end of the boiling-house. If at one end, the boiler called the *teache* is placed at the other, and several boilers (generally three) are ranged between them. The *teache* is ordinarily from 70 to 100 gallons, and the boilers between the clarifiers and *teache* diminish in size from the first to the last. Where the clarifiers are in the middle, there is usually a set of three boilers of each side, which constitute in effect a double boiling-house. On very large estates this arrangement is found useful and necessary. The objection to so great a number is the expence of fuel; to obviate which, in some degree, the three boilers on each side of the clarifiers are commonly hung to one fire.

²⁵ The clarifier, The juice runs from the receiver along a wooden gutter lined with lead into the boiling-house, where it is received into one of the clarifiers. When the clarifier is filled, a fire is lighted, and a quantity of Bristol quicklime in powder, which is called *temper*, is poured into the vessel. The use of the lime is to unite with the superabundant acid, which, for the success of the process, it is necessary to get rid of. The quantity sufficient to separate the acid must vary according to the strength of the quicklime and the quality of the liquor. Some planters allow a pint of lime to every 100 gallons of liquor; but Mr Edwards thinks that little more than half the quantity is a better medium proportion, and even then, that it ought to be dissolved in boiling water, that as little of it as possible may be precipitated. The heat is suffered gradually to increase till it approaches within a few degrees of the heat of boiling water, that the impurities may be thoroughly separated. But if the liquor were suffered to boil with violence, the impurities would again incorporate with it. It is known to be sufficiently heated when the scum begins to rise in blisters, which break into white froth, and appear generally in about 40 minutes. The fire is then suddenly extinguished by means of a damper, which

excludes the external air, and the liquor is allowed to remain about an hour undisturbed, during which period the impurities are collected in scum on the surface. The juice is then drained off either by a syphon or a cock; the scum being of a tenacious gummy nature, does not flow out with the liquor, but remains behind in the clarifier. The liquid juice is conveyed from the clarifier by a gutter into the evaporating boiler, commonly termed the *grand copper*; and if it has been obtained from good canes it generally appears transparent.

²⁶ And four coppers. In the evaporating boiler, which should be large enough to receive the contents of the clarifier, the liquor is allowed to boil; and as the scum rises it is taken off. The scumming and evaporation are continued till the liquor becomes finer and thicker, and so far diminished in bulk that it may be easily contained in the second copper. When put into the second copper, it is nearly of the colour of Madeira wine; the boiling and scumming are continued, and if the impurities be considerable, a quantity of lime-water is added. This process is carried on till the liquor be sufficiently diminished in quantity to be contained in the third copper. After being purified a third time, it is put into the fourth copper, which is called the *teache*, where it is boiled and evaporated till it is judged sufficiently pure to be removed from the fire. In judging of the purity of the liquor, many of the negroes (says Mr Edwards) guess solely by the eye (which by long habit they do with great accuracy), judging by the appearance of the grain on the back of the ladle: but the practice most in use is to judge by what is called the *touch*; i. e. taking up with the thumb a small portion of the hot liquor from the ladle; and, as the heat diminishes, drawing with the fore-finger the liquid into a thread. This thread will suddenly break, and shrink from the thumb to the suspended finger, in different lengths, according as the liquor is more or less boiled. The proper boiling height for strong muscovado sugar is generally determined by a thread of a quarter of an inch long. It is evident, that certainty in this experiment can be attained only by long habit, and that no verbal precepts will furnish any degree of skill in a matter depending wholly on constant practice.

²⁷ After being clarified it is cooled, granulated, and freed from its melasses. The juice being thus purified by passing through the clarifier and four coppers, it is poured into coolers, which are usually six in number. The removal from the *teache* to the cooler is called *striking*. The cooler is a shallow wooden vessel 7 feet long, from 5 to 6 wide, about 11 inches deep, and capable of containing a hoghead of sugar. As the liquor cools, the sugar grains, that is, collects into an irregular mass of imperfect crystals, separating itself from the melasses. It is then removed from the cooler, and conveyed to the curing-house, where the melasses drain from it. For receiving them there is a large cistern, the sloping sides of which are lined with boards. Directly above the cistern a frame of joist-work without boarding is placed, on which empty hogsheds without heads are ranged. The bottoms of these hogsheds are pierced with 8 or 10 holes, in each of which the stalk of a plantain leaf is fixed so as to project 6 or 8 inches below the joists, and rise a little above the top of the hoghead. The hogsheds being filled with the contents of the cooler, consisting of sugar and melasses, the melasses being liquid, drain through the spongy stalk, and drop into the cistern. After the melasses are drained off, the sugar becomes pretty dry and fair, and is then called *muscovado* or *raw sugar*.

We have described the process for extracting sugar, which is generally adopted in the British West India islands, according to the latest improvements; and have been anxious to present it to our readers in the simplest and most perspicuous form, that it might be intelligible to every person; and

Sugar.

have therefore avoided to mention the observations and proposed amendments of those who have written on this subject. Had we done so, we should have swelled the present article to too great a size, without accomplishing the purpose which we have in view; for our intention is not to instruct the planters, but to give a distinct account of the most approved methods which the planters have generally adopted. But though we judge it useless to trouble our readers with all the little varieties in the process which different persons employ, we flatter ourselves it will not be disagreeable to learn by what methods the French make their sugar purer and whiter

28
Method of
purifying
used by the
French.

than ours. A quantity of sugar from the cooler is put into conical pans or earthen pots, called by the French *formes*, having a small perforation at the apex, which is kept closed. Each cone, reversed on its apex, is supported in another earthen vessel. The syrup is stirred together, and then left to crystallize. At the end of 15 or 16 hours, the hole in the point of each cone is opened, that the impure syrup may run out. The base of these sugar loaves is then taken out, and white pulverized sugar substituted in its stead; which being well pressed down, the whole is covered with clay moistened with water. This water filters through the mass, carrying the syrup with it which was mixed with the sugar, but which by this management flows into a pot substituted in the place of the first. This second fluid is called *fine syrup*. Care is taken to moisten and keep the clay to a proper degree of softness as it becomes dry. The sugar loaves are afterwards taken out, and dried in a stove for eight or ten days; after which they are pulverized, packed, and exported to Europe, where they are still farther purified. The reason assigned why this process is not universally adopted in the British sugar islands is this, that the water which dilutes and carries away the molasses dissolves and carries with it so much of the sugar, that the difference in quality does not pay for the difference in quantity. The French planters probably think otherwise, upwards of 400 of the plantations of St Domingo having the necessary apparatus for claying and actually carrying on the system.

29
The art of
refining su-
gar intro-
duced by a
Venetian.

The art of refining sugar was first made known to the Europeans by a Venetian, who is said to have received 100,000 crowns for the invention. This discovery was made before the new world was explored; but whether it was an invention of the person who first communicated it, or whether it was conveyed from China, where it had been known for a considerable time before, cannot now perhaps be accurately ascertained. We find no mention made of the refining of sugar in Britain till the year 1659, though it probably was practised several years before. For in the Portuguese island of St Thomas in 1624 there were 74 sugar ingenios, each having upwards of 200 slaves. The quantity of raw sugar imported into England in 1778 amounted to 1,403,995 cwts.; the quantity imported into Scotland in the same year was 117,285 cwts.; the whole quantity imported into Great Britain in 1787 was 1,926,741 cwts.

Anderson's
Origin of
Commerce.

30
In refin-
ing it is
mixed with
lime-water
and bul-
lock's
blood, and
exposed to
heat.

The sugar which undergoes the operation of refining in Europe is either raw sugar, sometimes called *muscovado* or *cañonado*, which is raw sugar in a purer state. The raw sugar generally contains a certain quantity of molasses as well as earthy and feculent substances. The cañonado, by the operation of earthing, is freed from its molasses. As the intention of refining these sugars is to give them a higher degree of whiteness and solidity, it is necessary for them to undergo other processes. The first of these is called *clarification*. It consists in dissolving the sugar in a certain proportion of lime-water, adding a proper quantity of bullock's blood, and exposing it to heat in order to remove the impurities which still remain. The heat is increased very gradually till it approach that of boiling water.

By the assistance of the heat, the animal matter which was thrown in coagulates, at the same time that it attracts all the solid feculent and earthy matter, and raises it to the surface in the appearance of a thick foam of a brownish colour. As the feculencies are never entirely removed by a first process, a second is necessary. The solution is therefore cooled to a certain degree by adding some water; then a fresh quantity of blood, but less considerable than at first, is poured in. The fire is renewed, and care is taken to increase the heat gently as before. The animal substance seizes on the impurities which remain, collects them on the surface, and they are then skimmed off. The same operation is repeated a third and even a fourth time, but no addition is made to the liquor except water. If the different processes have been properly conducted, the solution will be freed from every impurity, and appear transparent. It is then conveyed by a gutter into an oblong basket about 16 inches deep, lined with a woollen cloth; and after filtering through this cloth, it is received in a cistern or copper which is placed below.

Sugar.

The solution being thus clarified, it undergoes a second general operation called *evaporation*. Fire is applied to the copper into which the solution was received, and the liquid is boiled till it has acquired the proper degree of consistency. A judgment is formed of this by taking up a small portion of the liquid and drawing it into a thread. When, after this trial, it is found sufficiently viscous, the fire is extinguished, and the liquid is poured into coolers. It is then stirred violently by an instrument called an *oar*, from the resemblance it bears to the oar of a boat. This is done in order to diminish the viscosity, and promote what is called the *granulation*, that is, the forming of it into grains or imperfect crystals. When the liquid is properly mixed and cooled, it is then poured into moulds of the form of a sugar loaf. These moulds are ranged in rows. The small ends, which are lowest, are placed in pots; and they have each of them apertures stopped up with linen for filtering the syrup, which runs from the moulds into the pots. The liquor is then taken out slowly in ladles from the coolers, and poured into the moulds. When the moulds are filled, and the contents still in a fluid state, it is necessary to stir them, that no part may adhere to the moulds, and that the small crystals which are just formed may be equally diffused thro' the whole mass. When the sugar is completely crystallized, the linen is taken away from the apertures in the moulds, and the syrup, or that part which did not crystallize, descends into the pots in which the moulds are placed. After this purgation the moulds are removed and fixed in other pots, and a stratum of fine white clay diluted with water is laid on the upper part of the loaf. The water descending thro' the sugar by its own weight, mixes with the syrup which still remains in the body of the loaf, and washes it away. When the clay dries, it is taken off, and another covering of moist clay put in its place; and if it be not then sufficiently washed, a third covering of clay is applied. After the loaves have stood some days in the moulds, and have acquired a considerable degree of firmness and solidity, they are taken out, and carried to a stove, where they are gradually heated to the 50° of Reaumur (64° of Fahrenheit), in order to dissipate any moisture which may be still confined in them. After remaining in the stove eight days, they are taken out; and after cutting off all discolouring specks, and the head if still wet, they are wrapped in blue paper, and are ready for sale. The several syrups collected during the different parts of the process, treated in the same manner which we have just described, afford sugars of inferior quality; and the last portion, which no longer affords any sugar, is sold by the name of *molasses*.

31
Then freed
from its re-
maining
impurities
by evapo-
ration.

32
Afterwards
poured into
moulds,
where the
syrup is
drained
from it.

33
Lastly ex-
posed to a
certain de-
gree of
heat.

The

Sugar.
34
In what
the beauty
of sugar
consists;
how far-
ther re-
fined.

35
How su-
gar-candy
is made.

36
Chemical
qualities of
sugar.

37
Its uses in
medicine,
&c.

The beauty of refined sugar, when formed into loaves, consists in whiteness, joined to a smallness of grain; in being dry, hard, and somewhat transparent. The process which we have described above refers to sugar once refined; but some more labour is necessary to produce double refined sugar. The principal difference in the operation is this, the latter is clarified by white of eggs instead of blood, and fresh water in place of lime-water.

Sugar-candy is the true essence of the cane formed into large crystals by a slow process. When the syrup is well clarified, it is boiled a little, but not so much as is done for the proof mentioned in the process for making common sugar. It is then placed in old moulds, having their lower ends stopped with linen, and crossed at little distances with small twigs to retain the sugar as it crystallizes. The moulds are then laid in a cool place. In proportion as the syrup cools crystals are formed. In about nine or ten days the moulds are carried to the stove, and placed in a pot; but the linen is not removed entirely, so that the syrup falls down slowly in drops. When the syrup has dropped away, and the crystals of the sugar-candy are become dry, the moulds are taken from the stove and broken in pieces, to disengage the sugar, which adheres strongly to the sides of the moulds. If the syrup has been coloured with cochineal, the crystals take a slight taint of red; if indigo has been mixed, they assume a bluish colour. If it be desired to have the candy perfumed, the essence of flowers or amber may be dropped into the moulds along with the syrup.

Having now given some account of the method usually employed for refining sugar, it will not be improper to say a few things concerning its nature and its uses.

Sugar is soluble in water, and in a small degree in alcohol. When united with a small portion of water, it becomes fusible; from which quality the art of preserving is indebted for many of its preparations. It is phosphoric and combustible; when exposed to fire emitting a blue flame if the combustion be slow, and a white flame if the combustion be rapid. By distillation it produces a quantity of phlegm, acid, oil, gas, and charcoal. Bergman, in treating sugar with the nitrous acid, obtained a new acid now known by the name of the *oxalic acid*: but he has omitted to mention the principles of which sugar is composed. Lavoisier, however, has supplied this omission; and after many experiments has assigned three principles in sugar, hydrogen, oxygen, and carbone. If the juice expressed from the sugar-cane be left to itself, it passes into the acetous fermentation; and during the decomposition of the sugar, which is continued for three or four months, a great quantity of glutinous matter is separated. This matter when distilled gives a portion of ammoniac. If the juice be exposed to the spirituous fermentation, a wine is obtained analogous to cyder. If this wine, after being kept in bottles a year, be distilled, we obtain a portion of *eau de vie*.

The uses to which sugar are applied are indeed numerous and important: It can be made so solid as in the art of preserving to receive the most agreeable colours and the greatest variety of forms. It can be made so fluid as to mix with any soluble substance.—It preserves the juice and substance of fruits in all countries and in all seasons. It affords a delicious seasoning to many kinds of food. It is useful in pharmacy, for it unites with medicines, and removes their disagreeable flavour: it is the basis of all syrups. M. Macquer has shown in a very satisfactory manner how useful sugar would be if employed in fermenting wines. Sugar has also been found a remedy for the scurvy, and a valuable article of food in cases of necessity. M. Imbert de Lennes, first surgeon to the late Duke of Orleans, publishes the following story in the *Gazette de Santé*, which confirms

this assertion. A vessel laden with sugar bound from the West Indies was becalmed in its passage for several days, during which the stock of provisions was exhausted. Some of the crew were dying of the scurvy, and the rest were threatened with a still more terrible death. In this emergency recourse was had to the sugar. The consequence was, the symptoms of the scurvy went off, the crew found it a wholesome and substantial aliment, and returned in good health to France.

"Sugar (says Dr Rush) affords the greatest quantity of nourishment in a given quantity of matter of any substance in nature; of course it may be preserved in less room in our houses, and may be consumed in less time, than more bulky and less nourishing aliment. It has this peculiar advantage over most kinds of aliment, that it is not liable to have its nutritious qualities affected by time or the weather; hence it is preferred by the Indians in their excursions from home. They mix a certain quantity of maple sugar, with an equal quantity of Indian corn, dried and powdered, in its milky state. This mixture is packed in little baskets, which are frequently wetted in travelling, without injuring the sugar. A few spoonfuls of it mixed with half a pint of spring water afford them a pleasant and strengthening meal. From the degrees of strength and nourishment which are conveyed into animal bodies by a small bulk of sugar, it might probably be given to horses with great advantage, when they are used in places or under circumstances which make it difficult or expensive to support them with more bulky or weighty aliment. A pound of sugar with grass or hay has supported the strength and spirits of an horse during a whole day's labour in one of the West-India Islands. A larger quantity given alone has fattened horses and cattle, during the war before last in Hispaniola, for a period of several months, in which the exportation of sugar, and the importation of grain, were prevented by the want of ships.

"The plentiful use of sugar in diet is one of the best preventives that has ever been discovered of the diseases which are produced by worms. Nature seems to have implanted a love for this aliment in all children, as if it were on purpose to defend them from those diseases. Dr Rush knew a gentleman in Philadelphia, who early adopted this opinion, and who, by indulging a large family of children in the use of sugar, has preserved them all from the diseases usually occasioned by worms.

"Sir John Pringle has remarked, that the plague has never been known in any country where sugar composes a material part of the diet of the inhabitants. Dr Rush thinks it probable that the frequency of malignant fevers of all kinds has been lessened by this diet, and that its more general use would defend that class of people who are most subject to malignant fevers from being so often affected by them.

"In the numerous and frequent disorders of the breast, which occur in all countries where the body is exposed to a variable temperature of weather, sugar affords the basis of many agreeable remedies. It is useful in weakneses, and acrid defluxions upon other parts of the body. Many facts might be adduced in favour of this assertion. Dr Rush mentions only one, which, from the venerable name of the person whose case furnished it, cannot fail of commanding attention and credit. Upon my inquiring of Dr Franklin, at the request of a friend (says our respectable author), about a year before he died, whether he had found any relief from the pain of the stone from the blackberry jam, of which he took large quantities, he told me that he had, but that he believed the medicinal part of the jam resided wholly in the sugar; and as a reason for thinking so, he added, that he often found the same relief by taking about half a pint of a syrup.

Sugar.

38

Affords the
greatest
quantity of
nourish-
ment of
any kind
of food.

Transactions
of the Ame-
rican Philo-
sophical So-
ciety, vol. iii.

39

An excel-
lent anti-
dote against
worms,

40

And proba-
bly against
the plague
and other
malignant
fevers.

41

Has given
relief from
the pain of
the stone.

Sugar.

symp, prepared by boiling a little brown sugar in water, just before he went to bed, that he did from a dose of opium. It has been supposed by some of the early physicians of our country, that the sugar obtained from the maple-tree is more medicinal than that obtained from the West India sugar-cane; but this opinion I believe is without foundation. It is preferable in its qualities to the West-India sugar only from its superior cleanliness.

42
Not hurt-
ful to the
teeth.

"Cases may occur in which sugar may be required in medicine, or in diet, by persons who refuse to be benefited, even indirectly by the labour of slaves. In such cases the innocent maple sugar will always be preferred. It has been said, that sugar injures the teeth; but this opinion now has so few advocates, that it does not deserve a serious refutation."

43
Sugar ma-
nufactured
in the East
Indies by
freemen,

In the account which we have given above of the method of cultivating and manufacturing sugar, we have had in our eye the plantations in the West Indies, where slaves alone are employed; but we feel a peculiar pleasure in having it in our power to add a short description of the method used in the East Indies, because there sugar is manufactured by free men, on a plan which is much more economical than what is followed in the West Indies. The account which we mean to give is an extract from the report of the committee of Privy-council for trade on the subject of the African slave-trade, drawn up by Mr Botham. We shall give it in the author's own words.

44
Of a supe-
rior quality
and at a
lower
price.

"Having been for two years in the English and French West-Indian islands, and since conducted sugar estates in the East-Indies; before the abolition of the slave-trade was agitated in parliament, it may be desirable to know that sugar of a superior quality and inferior price to that in our islands is produced in the East-Indies; that the culture of the cane, the manufacture of the sugar and arrack, is, with these material advantages, carried on by free people. China, Bengal, the coast of Malabar, all produce quantities of sugar and spirits; but as the most considerable growth of the cane is carried on near Batavia, I shall explain the improved manner in which sugar estates are there conducted. The proprietor of the estate is generally a wealthy Dutchman, who has erected on it substantial mills, boiling and curing houses. He rents this estate to a Chinese, who resides on it as a superintendant; and this renter (supposing the estate to consist of 300 or more acres) lets it to freemen in parcels of 50 or 60 on these conditions: "That they shall plant it in canes, and receive so much *per pecul* of 133½ pounds for every *pecul* of sugar that the canes shall produce."

45
How sugar
estates are
managed at
Batavia.

When crop time comes on, the superintendant collects a sufficient number of persons from the adjacent towns or villages, and takes off his crop as follows. To any set of tradesmen who bring their carts and buffaloes he agrees to give such a price *per pecul* to cut all his crop of canes, carry them to the mill and grind them. A second to boil them *per pecul*. A third to clay them and basket them for market *per pecul*. So that by this method of conducting a sugar estate the renter knows to a certainty what the produce of it will cost him *per pecul*. He has not any permanent or unnecessary expence; for when the crop is taken off, the taskmen return to their several pursuits in the towns and villages they came from; and there only remains the cane planters who are preparing the next year's crop. This like all other complex arts, by being divided into several branches, renders the labour cheaper and the work more perfectly done.

Only clayed sugars are made at Batavia; these are in quality equal to the best sort from the West Indies, and are sold so low from the sugar estates as eighteen shillings sterling *per pecul* of 133½ lbs. This is not the selling price to the

trader at Batavia, as the government there is arbitrary, and sugar subject to duties imposed at will. The Shabander exacts a dollar *per pecul* on all sugar exported. The price of common labour is from 9d to 10d *per day*. By the method of carrying on the sugar estates, the taskmen gain considerably more than this not only from working extraordinary hours, but from being considered artists in their several branches. They do not make spirits on the sugar estates. The melasses is sent for sale to Batavia, where one distillery may purchase the produce of an hundred estates. Here is a vast saving and reduction of the price of spirits; not as in the West Indies, a distillery, for each estate; many centre in one, and arrack is sold at Batavia from 21 to 25 rix-dollars *per leaguer* of 160 gallons; say 8d *per gallon*.

The SUGAR MAPLE, (the *acer saccharinum* of Linnæus), as well as the sugar-cane, produces a great quantity of sugar. This tree grows in great numbers in the western counties of all the middle states of the American union. Those which grow in New York and Pennsylvania yield the sugar in a greater quantity than those which grow on the waters of Ohio.—These trees are generally found mixed with the beech, hemlock, white and water ash, the cucumber-tree, linden, aspen, butter nut, and wild cherry trees. They sometimes appear in groves covering five or six acres in a body, but they are more commonly interspersed with some or all of the forest trees which have been mentioned. From 30 to 50 trees are generally found upon an acre of ground. They grow only in the richest soils, and frequently in stony ground. Springs of the purest water abound in their neighbourhood. They are, when fully grown, as tall as the white and black oaks, and from two to three feet in diameter. They put forth a beautiful white blossom in the spring before they show a single leaf. The colour of the blossom distinguishes them from the *acer rubrum*, or the common maple, which affords a blossom of a red colour. The wood of the sugar maple-tree is extremely inflammable, and is preferred upon that account by hunters and surveyors for firewood. Its small branches are so much impregnated with sugar as to afford support to the cattle, horses, and sheep of the first settlers, during the winter, before they are able to cultivate forage for that purpose. Its ashes afford a great quantity of potash, exceeded by few, or perhaps by none, of the trees that grow in the woods of the United States. The tree is supposed to arrive at its full growth in the woods in twenty years.

It is not injured by tapping; on the contrary, the oftener it is tapped, the more syrup is obtained from it. In this respect it follows a law of animal secretion. A single tree had not only survived, but flourished after forty-two tapplings in the same number of years. The effects of a yearly discharge of sap from the tree, in improving and increasing the sap, are demonstrated from the superior excellence of those trees which have been perforated in an hundred places, by a small wood-pecker which feeds upon the sap. The trees, after having been wounded in this way, distil the remains of their juice on the ground, and afterwards acquire a black colour. The sap of these trees is much sweeter to the taste than that which is obtained from trees which have not been previously wounded, and it affords more sugar.

From twenty-three gallons and one quart of sap, procured in twenty-four hours from only two of these dark coloured trees, Arthur Noble, Esq; of the state of New York, obtained four pounds and thirteen ounces of good grained sugar.

A tree of an ordinary size yields in a good season from twenty to thirty gallons of sap, from which are made from five to six pounds of sugar. To this there are sometimes remarkable exceptions. Samuel Lowe, Esq; a justice of peace at

Sugar.

46
Description
of the sugar
maple.

Transactions
of the Ame-
rican Philo-
sophical So-
ciety, vol. iii.

47
The oftener
this tree
is tapped
the more
syrup is ob-
tained from
it.

48
What quan-
tity of sap
will pro-
duce a cer-
tain quan-
tity of su-
perior gar.

Sugar. peace in Montgomery county, in the state of New York, informed Arthur Noble, Esq; that he had made twenty pounds and one ounce of sugar between the 14th and 23d of April, in the year 1789, from a single tree that had been tapped for several successive years before.

49 This quantity might be increased by culture. From the influence which culture has upon forest and other trees, it has been supposed, that by transplanting the sugar maple-tree into a garden, or by destroying such other trees as shelter it from the rays of the sun, the quantity of the sap might be increased, and its quality much improved. A farmer in Northampton county, in the state of Pennsylvania, planted a number of these trees above twenty years ago in his meadow, from three gallons of the sap of which he obtains every year a pound of sugar. It was observed formerly, that it required five or six gallons of the sap of the trees which grow in the woods to produce the same quantity of sugar.

50 The sap distils from the wood of the tree. Trees which have been cut down in the winter for the support of the domestic animals of the new settlers, yield a considerable quantity of sap as soon as their trunks and limbs feel the rays of the sun in the spring of the year. It is in consequence of the sap of these trees being equally diffused through every part of them, that they live three years after they are girdled, that is, after a circular incision is made through the bark into the substance of the tree for the purpose of destroying it. It is remarkable that grass thrives better under this tree in a meadow, than in situations exposed to the constant action of the sun. The season for tapping the trees is in February, March, and April, according to the weather which occurs in these months.

51 Is increased by warm days and frosty nights. Warm days and frosty nights are most favourable to a plentiful discharge of sap. The quantity obtained in a day from a tree is from five gallons to a pint, according to the greater or less heat of the air. Mr Lowe informed Arthur Noble, Esq; that he obtained near three and twenty gallons of sap in one day (April 14. 1789.) from the single tree which was before mentioned. Such instances of a profusion of sap in single trees are however not very common.

52 How the sap is drained from the tree. There is always a suspension of the discharge of sap in the night if a frost succeed a warm day. The perforation in the tree is made with an axe or an auger. The latter is preferred from experience of its advantages. The auger is introduced about three quarters of an inch, and in an ascending direction (that the sap may not be frozen in a slow current in the mornings or evenings), and is afterwards deepened gradually to the extent of two inches. A spout is introduced about half an inch into the hole made by this auger, and projects from three to twelve inches from the tree. The spout is generally made of the sumach or elder, which usually grows in the neighbourhood of the sugar trees. The tree is first tapped on the south side; when the discharge of its sap begins to lessen, an opening is made on the north side, from which an increased discharge takes place. The sap flows from four to six weeks, according to the temperature of the weather. Troughs large enough to contain three or four gallons made of white pine, or white ash, or of dried water ash, aspen, linden, poplar, or common maple, are placed under the spout to receive the sap, which is carried every day to a large receiver, made of either of the trees before mentioned. From this receiver it is conveyed, after being strained, to the boiler.

53 Is reduced to sugar by three modes. We understand that there are three modes of reducing the sap to sugar; by evaporation, by freezing, and by boiling; of which the latter is most general, as being the most expeditious. We are farther assured, that the profit of the maple tree is not confined to its sugar. It affords most agreeable melasses, and an excellent vinegar. The sap which is suitable for these purposes is obtained after the sap

which affords the sugar has ceased to flow, so that the manufactories of these different products of the maple-tree, by succeeding, do not interfere with each other. The melasses may be made to compose the basis of a pleasant summer beer. The sap of the maple is moreover capable of affording a spirit; but we hope this precious juice will never be prostituted to this ignoble purpose. Should the use of sugar in diet become more general in this country (says Dr Rush), it may tend to lessen the inclination or supposed necessity for spirits, for I have observed a relish for sugar in diet to be seldom accompanied by a love for strong drink.

There are several other vegetables raised in our own country which afford sugar; as beet-roots, skirrets, parsneps, potatoes, celeri, red-cabbage stalks, the young shoots of Indian wheat. The sugar is most readily obtained from these, by making a tincture of the subject in rectified spirit of wine; which, when saturated by heat, will deposit the sugar upon standing in the cold.

SUGAR of Milk. See *Sugar of MILK.*

Acid of SUGAR. See *CHEMISTRY-Index.*

SUGILLATION, in medicine, an extravasation of blood in the coats of the eye, which at first appears of a reddish colour, and afterwards livid or black. If the disorder is great, bleeding and purging are proper, as are also discutients.

SUICIDE, the crime of self-murder, or the person who commits it.

We have often wished to see a history of crimes drawn up by a man of ability and research. In this history we would propose that the author should describe the crimes peculiar to different nations in the different stages of society, and the changes which they undergo in the progress of civilization. After having arranged the historical facts, he might, by comparing them with the religion and the knowledge of the people, deduce some important general conclusions, which would lead to a discovery of the cause of crimes, and of the remedy most proper to be applied. Some crimes are peculiar to certain stages of society, some to certain nations, &c.

Suicide is one of those crimes which we are led to believe not common among savage nations. The first instances of it recorded in the Jewish history are those of Saul and Ahi-Jehophel; for we do not think the death of Samson a proper example. We have no reason to suppose that it became common among the Jews till their wars with the Romans, when multitudes slaughtered themselves that they might not fall alive into the hands of their enemies. But at this period the Jews were a most desperate and abandoned race of men, had corrupted the religion of their fathers, and rejected that pure system which their promised Messiah came to Jerusalem to announce.

When it became remarkable among the Greeks, we have not been able to discover; but it was forbidden by Pythagoras, as we learn from Athenæus, by Socrates and Aristotle, and by the Theban and Athenian laws. In the earliest ages of the Roman republic it was seldom committed; but when luxury and the Epicurean and Stoical philosophy had corrupted the simplicity and virtue of the Roman character, then they began to seek shelter in suicide from their misfortunes or the effects of their own vices.

The religious principles of the bramins of India led them to admire suicide on particular occasions as honourable. Accustomed to abstinence, mortification, and the contempt of death, they considered it as a mark of weakness of mind to submit to the infirmities of old age. We are informed that the modern Gentoos, who still in most things conform to the customs of their ancestors, when old and infirm, are frequently brought to the banks of rivers, particularly to those

Sugar
||
Suicide.

54
Sugar procured from many other vegetables.

5
Suicide among the Jews.

2
Among the Greeks.

3
The Bramins and Gentoos.

Suicide. those of the Ganges, that they may die in its sacred streams, which they believe can wash away the guilt of their sins. **Sullivan's Phil. Rhaps. vol. ii.** But the maxims of the bramins, which have encouraged this practice, we are assured by Mr Holwell, are a corruption of the doctrines of the Shaftah, which positively forbid suicide under the severest punishment. **Holwell's Interesting Events, &c. vol. i.** The practice which religion or affection has established among the Gentoos for women at the death of their husbands to burn themselves alive on the funeral pile, we do not think ought to be considered as suicide, as we are not anxious to extend the meaning of the word; for were we to extend it thus far, it would be as proper to apply it to those who choose rather to die in battle than make their escape at the expence of their honour. Thus we should condemn as suicides the brave Spartans who died at Thermopylae in defence of their country; we should also be obliged to apply the same disgraceful epithet to all those well-meaning but weak-minded Christians in this island, who in the last century chose rather to die as martyrs than comply with commands which were not morally wrong. According to the Gentoo laws, "it is proper for a woman after her husband's death to burn herself in the fire with his corpse. Every woman who thus burns shall remain in paradise with her husband three crore and fifty lacks of years. If she cannot, she must in that case preserve an inviolable chastity. If she remain chaste, she goes to paradise; and if she do not preserve her chastity, she goes to hell."

4 Among the Americans. Robertson's America. A custom similar to this prevailed among many nations on the continent of America. When a chief died, a certain number of his wives, of his favourites, and of his slaves, were put to death, and interred together with him, that he might appear with the same dignity in his future station, and be waited upon by the same attendants. This persuasion is so deeply rooted, that many of their retainers offer themselves as victims; and the same custom prevails in many of the negro nations in Africa.

5 The Japanese, and If we can believe the historians of Japan, voluntary death is common in that empire. The devotees of the idol Amida drown themselves in his presence, attended by their relations and friends, and several of the priests, who all consider the devoted person as a saint who is gone to everlasting happiness. Such being the supposed honours appropriated to a voluntary death, it is not surprising that the Japanese anxiously cherish a contempt of life. Accordingly it is a part of the education of their children "to repeat poems in which the virtues of their ancestors are celebrated, an utter contempt of life is inculcated, and suicide is set up as the most heroic of actions."

6 Scythians, A notion seems also to have prevailed among the ancient Scythian tribes, that it was pusillanimous and ignoble for a man whose strength was wasted with disease or infirmity, so as to be useless to the community, to continue to live. It was reckoned an heroic action voluntarily to seek that death which he had not the good fortune to meet in the field of battle. Perversion of moral feeling does not spring up, we hope, spontaneously in any nation, but is produced by some peculiarities of situation. A wandering people like the Scythians, who roamed about from place to place, might often find it impossible to attend the sick, or to supply from their precarious store the wants of the aged and infirm. The aged and infirm themselves, no longer able to support the character of warriors, would find themselves unhappy. In this way the practice of putting to death such persons as were useless to the community might originate, and afterwards be inculcated as honourable; but he who put an end to his infirmities by his own hand, obtained a character still more illustrious.

The tribes of Scandinavia, which worshipped Odin the

"father of slaughter," were taught, that dying in the field of battle was the most glorious event that could befall them. This was a maxim suited to a warlike nation. In order to establish it more firmly in the mind, all were excluded from Odin's feast of heroes who died a natural death. In Asgardia stood the hall of Odin; where, seated on a throne, he received the souls of his departed heroes. This place was called *Valhalla*, signifying "the hall of those who died by violence." Natural death being thus deemed inglorious, and punished with exclusion from Valhalla the paradise of Odin, he who could not enjoy death in the field of battle was led to seek it by his own hands when sickness or old age began to assail him. In such a nation suicide must have been very common.

As suicide prevailed much in the decline of the Roman empire, when luxury, licentiousness, profligacy, and false philosophy, pervaded the world, so it continued to prevail even after Christianity was established. The Romans, when they became converts to Christianity, did not renounce their ancient prejudices and false opinions, but blended them with the new religion which they embraced. The Gothic nations also, who subverted the Roman empire, while they received the Christian religion, adhered to many of their former opinions and manners. Among other criminal practices which were retained by the Romans and their conquerors, that of suicide was one; but the principles from which it proceeded were explained, so as to appear more agreeable to the new system which they had espoused. It was committed, either to secure from the danger of apostacy, to procure the honour of martyrdom, or to preserve the crown of virginity.

When we descend to modern times, we lament to find so many instances of suicide among the most polished nations, who have the best opportunities of knowing the atrocity of that unnatural crime. The English have long been reproached by foreigners for the frequent commission of it; and the "gloomy month of November" has been stigmatized as the season when it is most common. But this disgraceful imputation, we think, may be justly attributed, not to the greater frequency of the crime in England than in other places, but to the custom of publishing in the newspapers every instance of suicide which is known. Mr Moore, who lately published a full inquiry into this subject, was at great pains to obtain accurate information concerning the perpetration of this crime in different countries. Mercier, who wrote in 1782, says, that the annual number of suicides in Paris was then about 150. He does not tell us how he came by the information; but we have the authority of the Abbé Fontana for asserting, that more persons put an end to their lives in Paris than in London. The Abbé had this information from the lieutenant of the police. Mr Moore was informed by one of the principal magistrates of Geneva, that in that city, which contains about 25,000 inhabitants, the average number of suicides is about eight. The average number of suicides, from what cause soever, for the last 28 years, has been 32 each year for London, Southwark, and Westminster. In Edinburgh, which contains 80,000 inhabitants, we are convinced the average number of suicides does not exceed four. Mr Moore found, from the accounts with which he was favoured by the several coroners of the county of Kent, that for the last 18 years the number has been upwards of 32 each year. Kent is supposed to contain 200,000 inhabitants, and London 800,000. It is easy therefore to see, that in the metropolis many instances of suicide must occur which are never the subject of legal inquiry, and consequently never made known to the world. Whereas in the country towns and villages of Kent it is scarcely possible to conceal such an action as self-murder from

Suicide.
And Scandinavians.

It prevailed much in the decline of the Roman empire.

Too common in modern times, but not more so in England than in other countries.

Mercier's *Tableau de Paris*. The number of suicides in Paris, London, Geneva, &c. according to the best accounts.

from the knowledge of the whole neighbourhood. The calculation therefore respecting Kent we may receive as true, while we must increase the average number in London very considerably. Mr Moore computes the average number of suicides in England every year at a thousand; but the principles on which he founds this opinion are so imperfect and vague, that we do not think it can be depended on as coming near the truth.

II
In what
rank and
situation
suicide is
most com-
mon.

Moore's
Full In-
quiry into
the Causes
of Suicide.

It might lead to some interesting conclusions to compare together, not only the number of suicides in different countries, but also the rank and principles, the sex and age, of those unhappy persons by whom it has been committed. Mercier says, that at Paris it was the lower ranks who were most commonly guilty of it; that it was mostly committed in garrets or hired lodgings; and that it proceeded from poverty and oppression. A great many, he says, wrote letters to the magistrates before their death. Mr Moore's correspondent from Geneva informed him, that from the year 1777 to 1787 more than 100 suicides were committed in Geneva; that two-thirds of these unfortunate persons were men; that few of the clerical order have been known to commit it; and that it is not so much the end of an immoral, irreligious, dissipated life, as the effect of melancholy and poverty. By the information obtained from the coroners of Kent, it appears, that of the 32, three-fourths have destroyed themselves by hanging; that the proportion of males to females has been about two-thirds of the former; that no one season of the year is more distinguished for this crime than another; and that suicide is upon the increase. Our accounts respecting the city of London are very imperfect; but we think ourselves intitled to conclude, that suicide is more common among the great and wealthy than among the lower ranks, and that it is usually the effect of gaming and dissipation.

12
Physical
causes to
which it
has been
ascribed in
Britain.

Those who have inquired into the causes of suicide in Britain have enumerated many physical as well as moral causes. They have ascribed it to the variableness of our climate, to the great use of animal food, to strong spirituous liquors, to tea, and to the sulphureous exhalations of the pit-coal used as fuel, which are said to produce a depression of spirits and nervous affections. Of our climate, we have no cause to complain, nor have we any reason to impute any of our vices to its influence. There are many climates much more unfavourable where suicide is scarcely known. That an excessive quantity of gross animal food, or of strong liquors, or of tea, will powerfully affect the human constitution, we will not deny; but before we consider these as causes, it must first be determined, whether those who are guilty of self-murder be much addicted to them; and if they are, whether there be not other causes much more violent in their nature which have operated on their mind; for we ought not rashly to attribute vicious effects to any of those things which seem to have been created on purpose for the comfort or convenience of man. We are rather surprised to find that coal is mentioned even as a distant cause of suicide; for it is one of the blessings of our island; and a good coal fire we have always found rather conducive to good spirits than injurious to them.

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Among the moral causes which are supposed to co-operate in producing suicide in Britain, the freedom of our constitution and laws is reckoned one. That rational liberty should have any tendency to encourage crimes of any kind, a Christian philosopher can never allow; for such an opinion is totally discountenanced by enlightened views of nature. Mercier has ascribed the frequency of suicide in Paris to the oppression of the late government. Now it appears somewhat extraordinary, that suicide in one country should be occasioned by liberty, and in another by the want of it. One of these opinions must be false, and it is surely not difficult to distinguish which.

Humanity would in most cases dispose us to conclude, that suicide is the effect of insanity, were there not so many instances of cool deliberate self-murder. That suicide is an unnatural crime, which none but a madman would commit, compassion indeed may suppose: but the murder of a wife, a father, or a child, are also unnatural; yet compassion does not teach us in all cases to ascribe such a crime to madness. Passion may often arise to such a height of outrage as to be scarcely distinguishable from madness in its symptoms and its effects; yet we always make a distinction between that madness which arises from disease and that which is owing to a violent perturbation of mind. If a person be capable of managing his worldly affairs, of making a will, and of disposing of his property, immediately before his death, or after he formed the resolution of dying by his own hands, such a man is not to be considered as insane.

But though a regard for truth prevents us from ascribing suicide in all cases to insanity, we must ascribe it either to insanity or to vicious passion. These two divisions, we imagine, will comprehend every species of it, whether arising from melancholy, *tedium vite* or *ennui*, disappointment in schemes of ambition or love, pride, gaming, or a desire to avoid the shame of a public execution; passions which are often increased by false views of God, of man, and of a future state, arising from deism and infidelity. If these be the causes of suicide in modern time, what a disgraceful contrast do they form to those principles which actuated many of the ancient philosophers, the Gentoos, the Japanese, and the worshippers of Odin? When they committed suicide, they committed it from principle, from a belief of its lawfulness, and the hope of being rewarded for what they judged an honourable sacrifice. But in modern times, we are sorry to say, when it is not the effect of madness, it is the effect of vice: and when it is the effect of vice, it proves that the vicious passions are then indulged to the highest degree; for there is no crime which a man can commit that is so strong a symptom of the violence of particular passions. It is from not attending to this circumstance, that it has been found so difficult to refute the arguments in favour of suicide. If the criminality of suicide be confined merely to the violent action, many apologies may be made for it; but if it be considered solely as the effect of vice, as the strongest symptom of ungoverned passion, he who undertakes its defence must undertake the defence of what all men will loudly condemn (A).

It is unnecessary then to enter particularly into the arguments

I

ments

(A) Several of the heathens entertained a very just sense of the atrocity of suicide. Quintus Curtius introduces Darius with the following speech, when he had lost his empire: "I wait (says the unfortunate monarch) the issue of my fate: you wonder, perhaps, that I do not terminate my own life; but I choose rather to die by the crime of another than by my own."

We cannot refuse ourselves the pleasure of presenting to our readers the following beautiful passage upon this subject from Fitzosborne's letters*: "I am persuaded (says this elegant writer) this disgust of life is frequently indulged out of a principle of mere vanity. It is esteemed as a mark of uncommon refinement, and as placing a man above the ordinary level."

* Letter
level

Suicide.
16
Unneces-
sary to en-
ter into the
arguments
of casuists
upon this
subject.

ments of those casuists who have undertaken the despicable office of advocates for the crime of suicide. Their talents might surely have been employed more usefully to the world, and more honourably to themselves, than in pleading for a crime which, if it were committed by every man to whom their principles would make it lawful, would totally destroy some of the noblest virtues, fortitude, patience, and resignation; nay, would destroy society itself, and teach us to despise the opinion that this world is a state of preparation for another. "I came into life without my own consent, and may I not quit it at pleasure?" (say the advocates for suicide). If, because we came into life without our own consent, we might quit it at pleasure, why may we not spend our life also as we please? Why may we not rob and murder, and commit every kind of crime, if *mere inclination* is to be the rule of action? Thus upon the principles of suicide the highwayman and murderer may reason, and every man may find a sufficient apology for any crime which he is tempted to commit. Or this absurdity may be otherwise answered; As we came into life without our own consent, we must have come with the consent of some other being; and logic says, that with the consent of that Being only can we lawfully quit it.

17
Its great
criminality
and impru-
dence.

It is sufficient shortly to say, that suicide is contrary to the strongest principle of the human constitution, self-preservation; that it is rebellion against God; that it is cruelty to the feelings and reputation, and often takes away the subsistence of a wife, a child, or a father; that it proves a want of fortitude to brave misfortunes; that it delivers only from imagined to plunge into real evils. We may add, that almost every instance of suicide of which we have heard was rash, imprudent, and premature, interrupted a useful life, or prevented a more honourable death. Had Cato's pride permitted him to yield himself to the generosity of Cæsar, his character and his influence might have contributed to retard the slavery of his country, which his death tended to hasten. Had Brutus and Cassius not executed the fatal resolution which they had formed, of dying by their own hands in case of misfortune, the battle of Philippi might have had a very different issue. Had Hannibal surrendered himself to the Romans, instead of swallowing poison, he would have gained more glory in braving

their tortures than he won in the battle of Cannæ; for to die innocently and heroically is the greatest exertion of human fortitude.

As suicide was deemed a crime by the most illustrious and virtuous of the Greek and Roman philosophers, it was considered as a crime by the laws, and treated with ignominy. By the law of Thebes suicides were to have no honours paid to their memory†. The Athenian law ordained the hand which committed the deed to be cut off, and burned apart from the rest of the body. The body was not buried with the usual solemnities, but was ignominiously thrown into some pit. In Cea and Massilia (the ancient *Mar-seilles*), it was considered as a crime against the state; and it was therefore necessary for those who wished to destroy themselves to obtain permission from the magistrates. § Plutarch acquaints us, that an unaccountable passion for suicide seized the Milesian virgins; from indulging which they could not be prevented by the tears and entreaties of parents and friends: but what persuasion and entreaty could not effect was accomplished by very different means. A decree was issued, "that the body of every young woman who hanged herself should be dragged naked through the streets by the same rope with which she had committed the deed." This wise edict put a complete stop to the extraordinary frenzy, and suicide was no longer committed by the virgins of Miletus.

In the early part of the Roman history there seems to have been seldom occasion for framing any laws against suicide. The only instance recorded occurs in the reign of Tarquinius Priscus. The soldiers who were appointed to make drains and common sewers, thinking themselves disgraced by such servile offices, put themselves to death in great numbers. The king ordered the bodies of all the self-murderers to be exposed on crosses, and this put an effectual stop to the practice. It is doubtful whether there was any standing law against suicide during the existence of the republic; but during the reign of the emperors it was thought proper to lay it under certain regulations, though not absolutely to condemn it as a crime. In Justinian's Digests there is a law, by which it was enacted, "that if persons accused, or who had been found guilty, of any crime should make away with themselves, their effects should be confiscated."

level of his species, to seem superior to the vulgar feelings of happiness. True good sense, however, most certainly consists not in despising, but in managing our stock of life to the best advantage, as a cheerful acquiescence in the measures of Providence is one of the strongest symptoms of a well constituted mind. Self-weariness is a circumstance that ever attends folly; and to condemn our being is the greatest, and indeed the peculiar infirmity, of human nature. It is a noble sentiment which Tully puts into the mouth of Cato, in his Treatise upon old Age; *Non lubet mihi* (says that venerable Roman) *deplorare vitam, quod multi, et ii docti, sæpe fecerunt; neque me vixisse pœnitet: quoniam ita vixi, ut non frustra me natum exissem.*

"It is in the power, indeed, of but a very small portion of mankind to act the same glorious part that afforded such high satisfaction to this distinguished patriot; but the number is yet far more inconsiderable of those who cannot, in any station, secure themselves a sufficient fund of complacency to render life justly valuable. Who is it that is placed out of the reach of the highest of all gratifications, those of the generous affections, and that cannot provide for his own happiness, by contributing something to the welfare of others? As this disease of the mind generally breaks out with most violence in those who are supposed to be endowed with a greater delicacy of taste and reason than is the usual allotment of their fellow-creatures, one may ask them, whether there is any satiety in the pursuits of useful knowledge? or, if one can ever be weary of benefiting mankind? Will not the fine arts supply a lasting feast to the mind? or, can there be wanting a pleasurable enjoyment, so long as there remains even one advantageous truth to be discovered or confirmed? To complain that life has no joys, while there is a single creature whom we can relieve by our bounty, assist by our counsels, or enliven by our presence is, to lament the loss of that which we possess, and is just as rational as to die for thirst with the cup in our hands. But the misfortune is, when a man is settled into a habit of receiving all his pleasures from the mere selfish indulgences, he wears out of his mind the relish of every nobler enjoyment, at the same time that his powers of the sensual kind are growing more languid by each repetition. It is no wonder, therefore, he should fill up the measure of his gratifications long before he has completed the circle of his duration; and either wretchedly sit down the remainder of his days in discontent, or rashly throw them up in despair."

Suicide confiscated." But this punishment only took place when
 || confiscation of goods happened to be the penalty appointed
 SUT. by the law for the crime of which the self-murderer was
 accused or found guilty, and was not inflicted for suicide
 committed in any other circumstances.

20
 And by Christians. When the Christian church had extended its jurisdiction
 in the Roman empire, it was decreed in the sixth century,
 that no commemoration should be made in the eucharist for
 such as destroyed themselves; neither should their bodies be
 carried out to burial with psalms, nor have the usual service
 said over them. This ecclesiastical law continued till the re-
 formation, when it was admitted into the statute code of Eng-
 land by the authority of parliament. As an additional punish-
 ment, however, confiscation of land and goods seems to have

1 De Legibus et Consuetudinibus Angliae, lib. iii. Tract. 11.
 been adopted from the Danes, as we learn from Bracton †. At present the punishment consists in confiscating all the
 personal property of a *felo de se* for the use of the crown,
 and in excluding his body from interment in consecrated
 ground. The warrant of the coroner requires that the bo-
 dy should be buried in some public highway, and a stake
 driven through it to increase the ignominy.

21
 Difficult to devise a punishment that would be an effectual preventive.
 To inquire into the prevalence and causes of crimes, in or-
 der to discover the most judicious methods of preventing them,
 is the duty of the patriot and the Christian. Suicide, we
 find, is a common and an increasing evil: but it is a difficult
 matter to find an effectual remedy; for what motives can
 be held out sufficient to influence that man's mind who
 is deaf to the voice of nature speaking within him, and
 to the voice of nature's God declaring that he is sta-
 tioned at a post which it is his duty to maintain? His re-
 putation and property are indeed within the reach of the
 laws, his body may be treated with ignominy, and his pro-
 perty confiscated; but this punishment will not be a pre-
 ventive, even if it could be always inflicted; and that it is
 seldom inflicted, though the laws have decreed it, is well
 known. The humanity of the present age disposes us to
 sympathise with the relations of the deceased, instead of
 demanding that the sentence of the law should be exe-
 cuted. It is a generally received opinion, and a just one,
 that punishments decreed by human laws should be directed
 only against such crimes as are injurious to society; but
 when it is hence inferred, that suicide ought not to be sub-
 ject to the cognizance of human laws, every rule of logic is
 violated. There is no man, however mean in station and
 in talents, whose life may not, on some occasions, be useful
 to the community at large; and to conclude, that a person
 who fancies himself useless may therefore lawfully put a
 period to his life, is as false reasoning as it would be to
 conclude, that by killing a poor man, who lives on the public,
 we should perform an action not only innocent but meritori-
 ous, as we should thereby free society from one of its burdens.

SUIDAS, a Greek writer, according to some, flourished
 in the 11th century, under the reign of the Emperor Alexius
 Comnenus; according to others, before the 10th century.
 He wrote in Greek an Historical and Geographical Dictio-
 nary or Lexicon; a work which, though not always strict-
 ly accurate, is nevertheless of great importance, as it con-
 tains many things taken from the ancients that are no-
 where else to be found. The best edition of Suidas is
 that of Kuister, in Greek and Latin, with notes, printed
 in 3 vols fol. which has been much improved by Toup.

LAPIS SUILLUS. See *SWINE-STONE*.

SUIT, is used in different senses; as, 1. Suit of court,
 or suit-service, which is an attendance the tenant owes to
 his lord's court. 2. Suit-covenant, where a person has co-
 venanted to do service in the court of the lord. 3. Suit-
 custom, which is where one and his ancestors have owed

suit time out of mind. 4. It is used for a petition to the
 king or any person of dignity, where a lord distrains his te-
 nant for suit, and none is due. In this case, the party
 may have an attachment against him to appear in the king's
 court.

SUIT, in law, the same with action. The Romans in-
 troduced pretty early set forms for actions and suits into their
 law, after the example of the Greeks; and made it a rule,
 that each injury should be redressed by its proper remedy
 only. "*Actiones, (say the Pandects) compositae sunt quibus*
inter se homines disceptarent, quas actiones ne populus prout vellet
institueret, certas solemnesque esse voluerunt." The forms of
 these actions were originally preserved in the books of the
 pontifical college as choice and inestimable secrets, till one
 Cneius Flavius, the secretary of Appius Claudius, stole a
 copy and published them to the people. The conceal-
 ment was ridiculous: but the establishment of some stand-
 ard was undoubtedly necessary to fix the true state of a que-
 stion of right; lest, in a long and arbitrary process, it might
 be shifted continually, and be at length no longer discerni-
 ble. Or, as Cicero expresses it, "*sunt jura, sunt formulae,*
de omnibus rebus constituta, ne quis aut in genere injuria, aut in
ratione actionis, errare possit. Expressae enim sunt ex uniuscu-
jusque damno, dolore, incommodo, calamitate, injuria, publica à
pratore formulae, ad quas privata lis accommodatur." And in
 the same manner Bracton, speaking of the original writs
 upon which all our actions are founded, declares them to
 be fixed and immutable, unless by authority of parliament.
 And all the modern legislators of Europe have found it
 expedient, from the same reasons, to fall into the same
 or a similar method. In England, the several suits, or re-
 medial instruments of justice, are, from the subject of them,
 distinguished into three kinds; actions *personal, real, and*
mixed.

Personal actions are such whereby a man claims a debt,
 or personal duty, or damages in lieu thereof; and likewise
 whereby a man claims a satisfaction in damages for some in-
 jury done to his person or property. The former are said
 to be founded upon contracts, the latter upon *torts* or
 wrongs: and they are the same which the civil law calls
 "*actiones in personam, quae adversus eum intenduntur qui ex*
contractu vel delicto obligatus est aliquid dare vel concedere." Of
 the former nature are all actions upon debt or promises; of
 the latter are all actions of trespasses, nuisances, assaults, de-
 famatory words, and the like.

Real actions (or, as they are called in the Mirror, *feodal*
actions), which concern real property only, are such where-
 by the plaintiff, here called the *demandant*, claims title to
 have any lands or tenements, rents, commons, or other
 hereditaments, in fee-simple, fee-tail, or for term of life.
 By these actions formerly all disputes concerning real
 estates were decided; but they are now pretty generally
 laid aside in practice, upon account of the great nicety re-
 quired in their management, and the inconvenient length
 of their process; a much more expeditious method of try-
 ing titles being since introduced, by other actions personal
 and mixed.

Mixed actions are suits partaking of the mixture of the
 other two, wherein some real property is demanded, and
 also personal damages for a wrong sustained. As for in-
 stance, an action of waste: which is brought by him who
 hath the inheritance, in remainder or reversion, against the
 tenant for life, who hath committed waste therein, to recover
 not only the land wasted, which would make it merely a
 real action; but also treble damages, in pursuance of the
 statute of Gloucester, which is a personal recompense; and
 so both, being joined together, denominate it a *mixed action*.

Sully
||
Sulphur.

The orderly parts of a suit are these: 1. The original writ. 2. The process. 3. The pleadings. 4. The issue or demurrer. 5. The trial. 6. The judgment, and its incidents. 7. The proceedings in nature of appeals. 8. The execution. See these articles.

SULLY. See BETHUNE.

SULPHAT, in the new chemical nomenclature, denotes a compound of the sulphuric acid with some other substance.

SULPHUR, a well known substance, which is yellow, tasteless, hard, brittle, and when rubbed becomes electric. Its specific gravity is from 1,9 to 2,35. According to Bergman, it gently evaporates at 170, melts at 185, and flames at 302 of Fahrenheit. It burns with a blue flame, and a disagreeable suffocating smell; in close vessels it sublimes without decomposition, or only a decomposition proportionable to the quantity of air they contain; when melted it becomes red, but recovers its colour on cooling. It is insoluble in water, though by long trituration it is said water will take up some of it, but it is rather diffused than dissolved in it; neither can spirit of wine unite to it, except when both are in a vaporous state, and then 72 parts of spirit of wine take up 1 of sulphur; it is soluble in hot oils, and also in fixed alkalis, both in the dry and liquid way; it is decomposed by boiling in concentrated nitrous acid, partly decomposed and partly dissolved by the vitriolic and oxygenated muriatic acid. See CHEMISTRY-Index.

Sulphur was formerly supposed to consist of sulphuric acid and phlogiston, in the proportion of 60 parts of the former to 40 of the latter; but by the new system which is now generally adopted, sulphur is reckoned a simple substance, and the sulphuric acid a compound of sulphur and oxygen or vital air. This conclusion is founded on the following facts: 1. Sulphur does not burn unless vital air have access to it. 2. During combustion it absorbs vital air from the atmosphere. 3. The sulphuric produced by the combustion of sulphur is equal in weight to the sulphur employed and the quantity of air that has been consumed.

Sulphur is found sometimes pure, and sometimes in combination with other substances. Of pure sulphur there are seven varieties. 1. Transparent sulphur, in eight-sided crystals, with two truncated pyramids. It is generally deposited by water on the surface of calcareous spar. Cadiz sulphur is of this kind. 2. Transparent sulphur in irregular fragments. Such is the sulphur of Switzerland. 3. Whittish pulverulent sulphur, deposited in siliceous geodes. In Franche Comté there are flints full of sulphur. 4. Pulverulent sulphur deposited on the surface of mineral waters, such as those of Aix-la-Chapelle. 5. Crystalline sulphur that has been sublimed, found in the neighbourhood of volcanoes. 6. Pulverulent sulphur sublimed from volcanoes, found in abundance at Solfatara in the vicinity of Naples. 7. Sulphur in stalactites, formed by volcanic fires.

Sulphur is also found united with different substances, as with metals, when it is called *pyrites*; a short account of which may be seen under the article *PYRITES*. Sometimes it is combined with calcareous earth, as in fetid calcareous stones and swine stone. It has lately been discovered, that sulphur is formed by a natural process in animals and vegetables beginning to putrefy. It is found on stable walls and in privies. It is also extracted from vegetables, from dock-root, cochlearia, &c. M. Deyeux obtained it from the white of eggs. It has been also procured from horse-dung.

The sulphur used in Great Britain is generally brought in a pure state from volcanic countries, where it abounds in an inexhaustible quantity. It is well known, however, that

some of the metallic ores in this country abound with it; Sulphur. but from the common mode of purifying them, the sulphur is dissipated and lost. Dr Warton has shown, in a paper on lead-ore in the Philosophical Transactions, that not less than 700 tons are annually dissipated in the various lead-mines of England.

It is extracted from pyrites in the following manner in Saxony and Bohemia. The pyrites is put in small pieces into earthen tubes: one of the tubes is placed on a furnace, and the other passes into a square vessel of cast iron containing water. The sulphur is disunited by the heat from the pyrites, and passes into the vessel; but it is then very impure. It is afterwards melted in an iron ladle, when the earthy and metallic particles are deposited by their weight, and the sulphur being light rises to the top. It is then poured off into a copper boiler, where it is farther purified, and afterwards poured into cylindrical moulds of wood, from which it receives the shape in which it is usually sold.

When melted sulphur is gently heated, it flies off in a yellow powder, which is called *flowers of sulphur*. The operation is performed in this manner: Common sulphur in powder is put into an earthen cucurbit, to the top of which a number of earthen pots inserted in one another is fixed, known by the name of *aludels*. The cucurbit is then heated till the sulphur become liquid: it then rises and attaches itself to the sides of the aludels.

Sulphur combined with an alkali is called *hepar sulphuris*, *liver of sulphur*, because it resembles in colour the liver of animals. In the French nomenclature it is called *sulphure*, and by those British chemists who have adopted the new system *sulphuret*.

Water decomposes the sulphuret. The sulphur is precipitated by acids, when a particular gas is extricated commonly called *hepatic gas*, or, what is more expressive of its composition, *sulphurated hydrogenous gas*. The fetor of this gas is insufferable, and is fatal to animals. It communicates a green colour to syrup of violets, and burns with a light-blue flame. It acts on metals and metallic oxides, especially those of lead and bismuth, which it soon blackens. It is decomposed by vital air; and accordingly, when it comes into contact with atmospheric air, a portion of the sulphur is separated. For this reason sulphureous waters do not contain genuine liver of sulphur.

The mineral acids act differently on sulphur. If the sulphuric acid be boiled on sulphur, the acid acquires an amber colour, and a sulphureous smell; the sulphur melts and swims like oil. When cooled, it concretes into globules of a greenish hue; but a small portion of the sulphur is dissolved in the acid, which may be precipitated by an alkali. The flaming red nitrous acid acts powerfully on sulphur. When poured upon melted sulphur, it occasions detonation and inflammation. The common muriatic acid produces no effect upon it; but the oxygenated muriatic acid acts upon it with force.

Sulphur unites readily with all metallic substances, excepting gold, platina, and zinc; at least we have not found the means of uniting it with these directly, and without some intermediate substance. The degrees of affinity with which sulphur combines with those metals to which it may be readily united are different; for it not only unites more easily and abundantly with some than with others, but it also quits those with which it has a less affinity, to unite with others to which it has a stronger affinity.

The affinities of sulphur, according to Mr Geoffroy's table, are, fixed alkali, iron, copper, lead, silver, regulus of antimony, mercury, and gold; and, according to Mr Gellert's table, they are, iron, copper, tin, lead, silver, bismuth, regulus

Kirwan's
Mineralogy.

Tournefort's
Chemistry.

Sulphur. *regulus of antimony, mercury, arsenic, and cobalt*: gold and zinc are marked in this table as being incapable of uniting with sulphur.

The compounds formed by sulphur with different metals are different; but all of them possess a metallic lustre, without any ductility: these combinations of sulphur and of metals are very frequently found in a natural state. Almost all the metals which we dig from the earth are naturally found combined with sulphur, forming most of the ores and metallic minerals.

It is a curious phenomenon, that nitre mixed with sulphur burns rapidly, even in close vessels; this is easily explained by the new system. Nitre, when heat is applied to it, yields a great quantity of vital air; and sulphur is a combustible body, or, which is the same thing, has a strong attraction for vital air. As vital air is thus supplied, which is the only principle necessary to combustion, communication with the atmospheric air is unnecessary. The sulphur will burn till the whole vital air which the nitre furnishes be consumed. The products obtained by this process are different according to the proportions of nitre and sulphur which are employed. If eight parts of sulphur and one of nitre be set on fire in a close vessel, sulphuric acid is produced; and this is the method by which oil of vitriol or strong sulphuric acid was formerly made in Great Britain. The vessels in which the operation was performed were large glass balloons, with very large necks, each containing 400 or 500 pints. But it was attended with great expence, on account of the high price and brittleness of the balloons. A few years ago a cheaper method has been attempted with success in France. The sulphur is burned on a kind of grid-irons, in large apartments lined with lead. As the acid condenses it is conveyed by gutters into a reservoir, and afterwards concentrated. It must be observed, that the sulphuric acid thus obtained is always combined with a little sulphur and sulphat of pot-ash, a small quantity of aluminous sulphat and sulphat of lead; but these substances are in so small a proportion, that for common use it is not necessary to separate them. If necessary, however, it may easily be done by distilling the acid to dryness.

Gunpowder, the terrible effects of which are owing to its strong tendency to combustion, is a mixture of sulphur, nitre, and charcoal. (See GUNPOWDER). But there is another mixture of which sulphur is an ingredient still more violent in its effects: This is called *fulminating powder*, and is composed of three parts of nitre, two parts of the carbonate of pot-ash, and one of powdered sulphur. These being closely united together by trituration in a hot marble mortar, when exposed to a slight degree of heat, will melt, and produce a violent detonation like the report of a cannon. A dram of this mixture is sufficient for the experiment.

Sulphur is of great use in chemistry, in medicine, and the arts. Sulphur is useful in making some fusions, precipitations, and separations of metals and minerals; but is particularly useful, as being the substance from which the sulphuric acid is obtained. *Hepar sulphuris* is employed in chemistry for making several solutions.

Sulphur is employed in medicine both internally and externally. It is given either in flowers or in lozenges, made up with sugar, or joined to magnesia, crystals of tartar, manna, cassia, lenitive electuary, &c. Two or three drams generally prove laxative; and it is given in such doses in cases of piles, of uterine, and other hæmorrhagies; because it does not stimulate nor heat during its operation, nor leave a disposition to costiveness, as rhubarb, aloes, and other hot resinous purges do. Sulphur was formerly much recommended in coughs and diseases of the breast, but of late its virtues as a pectoral have been much doubted. When ap-

plied externally, it is mixed with some unctuous substance, as hogs lard, butter, &c. and is rubbed on such parts of the body as are affected with eruptions.

Some physicians and chemists, considering that sulphur is insoluble in water, and capable of resisting the action of most menstrua, have affirmed, that it can produce no effect when taken internally, single and unaltered; but this assertion seems to be without foundation; for it is certain, that the sweat and perspiration of those who take sulphur internally have a smell evidently sulphureous. Besides, sulphur is much more soluble than is generally believed. It is attacked by all oily and saponaceous substances, and consequently by almost all animal liquors.

We cannot easily form a very distinct and clear idea of the manner in which sulphur acts internally upon our bodies; but, from observations made upon its effects, it appears to be dividing, stimulating, and somewhat heating; it principally acts upon the perspirable parts of the body, the chief of which are the skin and lungs; and from this property it is particularly useful in some diseases of these parts.

Sulphur is also a powerful repellent, as appears from its curing several kinds of itch, merely by external application, in form of ointments and pomatums. Several mineral waters, which are drunk or used as baths for some diseases, owe their good qualities to sulphur contained in them.

Sulphur is also used in several arts. By means of it fine impressions of engraved stones are taken. Matches are formed of it; and its utility as an ingredient in the preparation of gunpowder and fireworks is well known. Lastly, it is used for whitening wool, silk, and many other matters exposed to its vapour during its combustion; the colours and redness of which could not be destroyed by any other substance, but are quickly effaced by this acid vapour.

SULPHUR-WORD, in botany. See *PROCEDANUM*.

SULPHURIC ACID, the name adopted by the French chemists for the vitriolic acid. It is formed by a combination of sulphur with vital air, as described under the article *SULPHUR*. When sulphur is burned with a low degree of heat, it burns with a blue flame, and diffuses a suffocating vapour, which, when collected, is called *sulphureous acid*. When sulphur is exposed to strong heat it burns rapidly, and emits a lively white flame, and has no smell; the residue is called *sulphuric acid*. The sulphureous is a weaker acid than the sulphuric, owing to its containing a less quantity of oxygen.

SULPICIA, an ancient Roman poetess, who lived under the reign of Domitian, and has been so much admired as to be termed the *Roman Sappho*. We have nothing, however, left of her writings but a satire, or rather the fragment of one, against Domitian, who published a decree for the banishment of philosophers from Rome: which satire is to be found in Scaliger's *Appendix Virgiliana*. She is mentioned by Martial and Sidonius Apollinaris; and is said to have addressed a poem on conjugal love to her husband Calenus, a Roman knight.

SULPIIUS (Severus), an ecclesiastical writer who flourished about the beginning of the 5th century, and was contemporary with Rufinus and St Jerome. He was the disciple of St Martin of Tours, whose life he has written; and the friend of Paulinus bishop of Nola, with whom he held an intimate correspondence. The principal of his works is his *Historia Sacra*, from the creation of the world to the consulate of Stilicho and Aurelian, about the year 400; in which his style is elegant beyond the age he lived in.

SULTAN, or **SOLDAN**, a title or appellation given to the emperor of the Turks.

Vattier will have the word Turkish, and to signify king of

Sulphur
||
Sultan.

Sulzer.

of kings; adding, that it was first given to the Turkish princes Angrolipex and Masgud, about the year 1055: others will have it originally Persian, alleging, in proof hereof, an ancient medal of Cosroe: others derive it from *soldanus*, *quasi solus dominus*: others from the Hebrew שָׁלַח, *shalat* or *sheleth*, "to rule, reign."

It had its rise under Mahmoud, son of Sebeſteghin, the first emperor of the dynasty of the Gaznevdes, towards the close of the fourth century of the era of the Hegira: when that prince going to Segestan to reduce Kalaf governor of that province, who affected the sovereignty, Kalaf was no sooner advertised of his coming than he went out to meet him, delivered the keys of his fortress, and owned him his *sultan*, that is, his lord or commander. The title pleased Mahmoud so well, that he assumed it ever afterwards; and from him it passed to his descendants, and to other Mahometan princes. It is chiefly confined to the Turkish and Persian monarchs.

SULZER (M.), a celebrated philosopher, was born at Winterthun, in the canton of Zurich, October 16. 1720. He was the youngest of 25 children. His early education did not promise much, tho' it was by no means neglected. He had little inclination for what is called in the schools the study of *humanity*, and made but a small progress in the learned languages, which were to prepare him for the study of theology, for which profession his parents designed him. At the age of 16, when he went to the academical school of Zurich, he had not the smallest notion of the sciences, or of elegant literature, and consequently no taste for study. The first incident that developed a hidden germ of philosophical genius, was his meeting with Wolfe's *Metaphysics*: this was the birth of his taste for science; but he wanted a guide. The clergyman with whom he lodged was an ignorant man; and the academical prelections were, as yet, above the reach of his comprehension. On the other hand, a sedentary life was not the thing he liked, nor to which he had been accustomed; and, moreover, a sociable turn of mind led him often into company, where he lost much time in frivolous amusements, yet without corrupting his morals. Who, that observed him at this period, says Mr Formey in his *Eulogium*, would have thought that Sulzer would one day be numbered among the most knowing and wise men of his time? The learned Gesner was the instrument of Providence that rendered Sulzer's inclination to study triumphant over his passion for amusement and company. Animated by the counsels and example of this worthy and learned man, he applied himself to philosophy and mathematics with great ardour, and resumed the pursuit of Grecian literature and the Oriental languages. The contemplation of nature became his noble and favourite passion. An ecclesiastical settlement in a rural scene, that exhibited happy objects and occasions for this delightful study, began to render his days happy and useful; and he published, in 1741, *Moral Contemplations of the Works of Nature*; and the year following an *Account* of a journey he had made through the Alps; which showed, at the same time, his knowledge of natural history, and the taste and sensibility with which he surveyed the beauties of nature, and the grandeur and goodness of its Author. He afterwards became private tutor to a young gentleman at Magdeburg. This procured him the acquaintance of Messrs Maupertuis, Euler, and Sack, which opened to his merit the path of preferment, and advanced him successively to the place of mathematical professor in the King's College at Berlin, in 1747, and to that of member of the Royal Academy in 1750.

In this last quality he distinguished himself in a very eminent manner, enriched the class of speculative philosophy with a great number of excellent memoirs, and was justly

considered as one of the first-rate metaphysicians in Germany. But his genius was not confined to this branch of science. His *Universal Theory of the Fine Arts* is a valuable production. A profound knowledge of the arts and sciences, and a perfect acquaintance with true taste, are eminently displayed in this work, and will secure to its author a permanent and distinguished rank in the republic of letters. The first volume of this excellent work was published in 1771; and the second in 1774. We shall not here give a catalogue of the writings of M. Sulzer; but we cannot help mentioning his *Remarks on the Philosophical Essays* of the late Mr Hume, as a work of real merit, which does justice to the acuteness, while it often detects the sophistry, of the British Bayle. The moral character of M. Sulzer was amiable and virtuous: sociability and beneficence were its characteristic lines; and his virtues were animated by that sacred philosophy that forms the Christian, ennobles man, and is the only source of that heart-felt serenity and sedate fortitude which support humanity, when every other object of confidence fails. His dying moments were calm, humble, and sublime; and when he expired, the placid and composed air of his countenance made his mourning friends doubt, for some time, whether it was death or sleep that had suspended his conversation. He had no enemy; and his friends were numerous, affectionate, and worthy of the tender returns he made them.

The king of Prussia distinguished him by repeated marks of munificence and favour. We learn, however, that his royal protector had never seen him before the end of the year 1777, though he had been member of the academy from the year 1750. The audience, indeed, though late vouchsafed, was honourable to M. Sulzer, with whom the monarch conversed for a long time with the greatest affability and condescension.

SUM, signifies the quantity that arises from the addition of two or more magnitudes, numbers, or quantities together.

SUMACH, in botany. See RHUS.

SUMATRA, an island of Asia, the most western of the Sunda Islands, and constituting on that side the boundary of the Eastern Archipelago. Its general direction is nearly north-west and south-east. The equator divides it into almost equal parts, the one extremity being in 5. 33. N. and the other in 5. 56. S. Lat. Acheen Head, at the north extremity of the island, is in longitude 95. 34. east. It lies exposed on the south-west side to the Indian Ocean; the north point stretches into the bay of Bengal; to the north-east it is divided from the peninsula of Malacca by the straits of that name; to the east by the straits of Banca, from the island of that name; to the south-east by the commencement of what are called the *Chinese Seas*; and on the south by the straits of Sunda, which separate it from the island of Java. It is about 900 miles in length, but from 100 to 150 only in breadth. No account had been given of this island by any Englishman till the year 1778, when Mr Charles Miller (son of the late botanical gardener) published an account of the manners of a particular district, in the 68th volume of the *Philosophical Transactions*. These were the Battas, a people who live in the interior parts, called the *Cassia Country*. They differ from all the other inhabitants in language, manners, and customs. They eat the prisoners whom they take in war, and hang up their skulls as trophies in their houses. He observes, however, that human flesh is eaten by them *in terrorem*, and not as common food, though they prefer it to all others, and speak with peculiar raptures of the soles of the feet and palms of the hands. They expressed much surprise that the white people did not kill, much less eat, their prisoners. From this

Sulzer

Sumatra.

Brooke's Gazetteer.

Sumatra. this country the greatest part of the cassia that is sent to Europe is procured. It abounds also with the camphire trees, which constitute the common timber in use; and in these trees the camphire is found native, in a concrete form. It is remarkable, that in this state it is sold to the Chinese at the price of 250 l. or 300 l. *per cwt.* but these dexterous artists contrive to furnish the Europeans with it at about a quarter of that price. In 1783, Mr Marsden, who had been secretary to the president and council of Fort Marlborough, published a History of Sumatra, with very copious particulars of the island. He represents it as surpassed by few in the beautiful indulgences of nature. A chain of high mountains runs through its whole extent; the ranges in many parts being double and treble; their altitude, though great, is not sufficient to occasion their being covered with snow during any part of the year. Between these ridges are extensive plains, considerably elevated above the surface of the maritime lands. In these the air is cool; and from this advantage they are esteemed the most eligible portion of the country, are the best inhabited, and the most cleared from woods, which elsewhere, in general, throughout Sumatra, cover both hills and valleys with an eternal shade. Here too are found many large and beautiful lakes, that facilitate much the communication between the different parts. The heat of the air is far from being so intense as might be expected from a country occupying the middle of the Torrid Zone; and it is more temperate than many regions within the Tropics; the thermometer at the most sultry hour, about two in the afternoon, generally fluctuating between 82 and 85 degrees. Mr Marsden divides the inhabitants into Malays, Achenese, Battas, Lampoons, and Rejangs; and he takes the latter as his standard of description, with respect to the persons, manners, and customs, of the inhabitants. They are rather below the middle stature; their bulk in proportion; their limbs for the most part slight, but well shaped, and particularly small at the wrists and ankles; and, upon the whole, they are gracefully formed. Their hair is strong, and of a shining black. The men are beardless, great pains being taken to render them so when boys, by rubbing their chins with a kind of quicklime. Their complexion is properly yellow, wanting the red tinge that constitutes a copper or tawny colour. They are in general lighter than the Mestees, or half breed, of the rest of India; those of the superior class, who are not exposed to the rays of the sun, and particularly their women of rank, approaching to a degree of fairness. If beauty consisted in this one quality, some of them would surpass our brunettes in Europe. The major part of the females are ugly, many of them even to disgust; yet among them are some whose appearance is strikingly beautiful, whatever composition of person, features, and complexion, that sentiment may be the result of. Some of the inhabitants of the hilly parts are observed to have the swelled neck or goitre; but they attempt no remedy for it, as these wens are consistent with the highest health. The rites of marriage among the Sumatrans consist simply in joining the hands of the parties, and pronouncing them man and wife without much ceremony, excepting the entertainment which is given upon the occasion by the father of the girl. The customs of the Sumatrans permit their having as many wives as they can purchase, or afford to maintain; but it is extremely rare that an instance occurs of their having more than one, and that only among a few of the chiefs. This continence they owe, in some measure, to their poverty. The dictates of frugality are more powerful with them than the irregular calls of appetite, and make them decline an indulgence from which their law does not restrain them. Mothers carry their children, not on the arm as our nurses do, but straddling on

the hip, and usually supported by a cloth which ties in a knot on the opposite shoulder. The children are nursed but little; are not confined by any swathing or bandages; and being suffered to roll about the floor, soon learn to walk and shift for themselves. When cradles are used, they swing suspended from the ceilings of the rooms.

The Sumatrans are so fond of cock-fighting, that a father on his death-bed has been known to desire his son to take the first opportunity of matching a cock for a sum equal to his whole property, under a blind conviction of its being invulnerable. When a cock is killed, or runs, the other must have sufficient spirit and vigour left to peck at him three times on his being held up to him for that purpose, or it becomes a drawn battle; and sometimes an experienced cocker will place the head of his vanquished bird in such an uncouth situation as to terrify the other, and render him unable to give this proof of victory.

The wild beasts of Sumatra are tigers, elephants, rhinoceroses, bears, and monkeys. The tigers prove to the inhabitants both in their journeys and even their domestic occupations most destructive enemies. The number of people annually slain by these rapacious tyrants of the woods is almost incredible. Whole villages have been depopulated by them; yet from a superstitious prejudice, it is with difficulty they are prevailed upon, by a large reward which the India Company offers, to use methods of destroying them, till they have sustained some particular injury in their own family or kindred. The size and strength of the species which prevails on this island is prodigious. They are said to break with a stroke of their fore paw the leg of a horse or a buffalo; and the largest prey they kill is without difficulty dragged by them into the woods. This they usually perform on the second night, being supposed on the first to gratify themselves with sucking the blood only. Time is by this delay afforded to prepare for their destruction, either by shooting them, or placing a vessel of water strongly impregnated with arsenic near the carcase, which is fastened to a tree to prevent its being carried off. The tiger having satiated himself with the flesh, is prompted to assuage his thirst with the tempting liquor at hand, and perishes in the indulgence. Their chief subsistence is most probably the unfortunate monkeys with which the woods abound. They are described as alluring them to their fate by a fascinating power, similar to what has been supposed of the snake; and, says Mr Marsden, "I am not incredulous enough to treat the idea with contempt, having myself observed, that when an alligator or a crocodile, in a river, comes under an overhanging branch of a tree, the monkeys, in a state of alarm and distraction, crowd to the extremity, and, chattering and trembling, approach nearer and nearer to the amphibious monster that waits to devour them as they drop, which their fright and number render almost unavoidable." These alligators likewise occasion the loss of many inhabitants, frequently destroying the people as they bathe in the river, according to their regular custom, and which the perpetual evidence of the risk attending it cannot deter them from. A superstitious idea of their sanctity also preserves them from molestation, although, with a hook of sufficient strength, they may be taken without much difficulty. The other animals of Sumatra are buffaloes, a small kind of horses, goats, hogs, deer, bullocks, and hog-deer. This last is an animal somewhat larger than a rabbit, the head resembling that of a hog, and its shanks and feet like those of the deer. The bezoar stone found on this animal has been valued at 10 times its weight in gold; it is of a dark brown colour, smooth on the outside; and the coat being taken off, it appears still darker, with strings running underneath the coat: it will swim on the top of the water. If it be infused

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fed in any liquid, it makes it extremely bitter: the virtues usually attributed to this stone are cleansing the stomach, creating an appetite, and sweetening the blood.

Of birds they have a greater variety than of beasts. The coo-ow, or Sumatran pheasant, is a bird of uncommon beauty. They have flocks of prodigious size, parrots, dung-hill fowls, ducks, the largest cocks in the world, wood-pigeons, doves, and a great variety of small birds, different from ours, and distinguished by the beauty of their colours. Of their reptiles, they have lizards, flying-lizards, and cameleons. The island swarms with insects, and their varieties are no less extraordinary than their numbers. Rice is the only grain that grows in the country; they have sugar-canes, beans, peas, radishes, yams, potatoes, pumpkins, and several kinds of pot-herbs unknown to Europe; and here are to be found most of the fruits to be met with in other parts of the East Indies, in the greatest perfection. Indigo, Brasil-wood, two species of the bread-fruit tree, pepper, benjamin, coffee, and cotton, are likewise the produce of this island, as well as cassia and camphire mentioned above. Here also is the cabbage-tree and silk cotton tree; and the forest contains a great variety of valuable species of wood, as ebony, pine, sandal, eagle or aloes, teak, manchineel, and iron-wood, and also the banyan tree. Gold, tin, iron, copper, and lead, are found in the country; and the former is supposed to be as plentiful here as in Peru or Mexico. The finest gold and gold-dust are found in the country of *Limbang*, immediately contiguous to the presidency of *Fort Marlborough*, to which the merchants repair annually for the purchase of opium, and such other articles as they may be in want of, and give for them gold of so pure a nature as to contain little or no alloy. The native indolence of the *Malay* disposition prevents them from collecting more than is sufficient to supply the few and simple wants of a race of men as yet unenlightened by civilization and science, and ignorant of the full extent of the advantages of the country inhabited by them. The roads leading to this golden country are almost impervious; affording only a scanty path to a single traveller, where whole nights must be passed in the open air, exposed to the malignant influence of a hostile climate, in a country infested by the most ferocious wild beasts. These are circumstances that have hitherto checked curiosity; but perseverance and studied precaution will surmount the obstacles they furnish, and such discoveries might be made as would amply compensate for the difficulties leading to them. The gold merchants who come from the neighbouring and less rich countries, give us such accounts of the facility of procuring gold as border nearly on the marvellous, and would be altogether incredible, if great quantities of that metal produced by them did not in some degree evince the certainty of their accounts.

This great abundance of gold in Sumatra induces Mr Marfden to suppose that island to be the Ophir of Solomon; a conjecture which, in his opinion, derives no small force from the word *Ophir's* being really a *Malay* substantive, of a compound sense, signifying a mountain containing gold. The natives, he confesses, have no oral tradition on the subject; and we have elsewhere made it probable, that Ophir was situated in a different quarter of the world (see *OPHIR*). Besides the metals and different species of wood which we have mentioned, Sumatra produces sulphur, arsenic, saltpetre, and bees-wax, with edible birds-nests, which are there commodities of great importance (see *BIRDS-NESTS*).

The English and Dutch have factories on this island; the principal one of the former being Fort Marlborough, on the south-west coast. The original natives of Sumatra are Pagans; but it is to be observed, that when the Sumatrans, or any of the natives of the eastern islands, learn to

read the Arabic character, and submit to circumcision, they are said to become Malays; the term *Malay* being understood to mean *Mussulman*. See *ACHEEN*.

SUMMARY, in matters of literature. See *ABRIDGEMENT*.

SUMMER, the name of one of the seasons of the year, being one of the quarters when the year is divided into four quarters, or one half when the year is divided only into two, summer and winter. In the former case, summer is the quarter during which, in northern climates, the sun is passing through the three signs Cancer, Leo, Virgo, or from the time of the greatest declination, till the sun come to the equinoctial again, or have no declination; which is from about the 21st of June till about the 22d of September. In the latter case, summer contains the six warmer months, while the sun is on one side of the equinoctial; and winter the other six months, when the sun is on the other side of it. It is said that a frosty winter produces a dry summer, and a mild winter a wet summer.

SUMMER-Islands. See *BERMUDAS*.

SUMMER Red-Bird. See *MUSCICAPA*.

SUMMIT, the top or vertex of any body or figure, as of a triangle, cone, pyramid, &c.

SUMMONS, in law, a citing or calling a person to any court, to answer a complaint or to give his evidence.

SUMMONS, in war. To summon a place, is to send a drum or trumpet to command the governor to surrender, and to declare that if the place be taken by storm, all must submit to the mercy of the conqueror. See *CAPITULATION* and *CHAMADE*.

SUMMUM BONUM, in ethics, the chief good.

SUMP, in metallurgy, a round pit of stone, lined with clay within, for the receiving the metal on its first fusion from the ore.

SUMP, in the British salt-works, where sea-water is boiled into salt, is the name of a sort of pond, which is made at some distance from the saltern on the sea-shore, between full sea and low water mark. From this pond a pipe is laid, through which, when the sea is in, the water runs into a well adjoining to the saltern; and from this well it is pumped into troughs, through which it is carried to the cisterns, in order to be ready to supply the pans. See *SALT*.

SUMPH, in mining, denotes a pit sunk down in the bottom of the mine, to cut or prove the lode still deeper than before; and in order to slope and dig it away if necessary, and also to drive on the lode in depth. The sumph principally serves as a basin or reservoir, to collect the water of a mine together, that it may be cleaned out by an engine or machine.

SUMPTER-HORSE, is a horse that carries provisions and necessaries for a journey.

SUMPTUARY LAWS (*Leges Sumptuariae*); are laws made to restrain excess in apparel, costly furniture, eating, &c.

Most ages and nations have had their sumptuary laws; and some retain them still, as the Venetians, &c. But it is observed, that no laws are worse executed than sumptuary laws. Political writers have been much divided in opinion with respect to the utility of these laws to a state. Montesquieu observes, that luxury is necessary in monarchies, as in France, but ruinous to democracies, as in Holland. With regard to England, whose government is compounded of both species, it may still be a dubious question, says Judge Blackstone, how far private luxury is a public evil; and as such cognizable by public laws.

The sumptuary laws of that ancient Locrian legislator Zaleucus are famous: by these it was ordained, that no woman should go attended with more than one maid in the

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the street except she were drunk : that she should not go out of the city in the night, unless she went to commit fornication : that she should not wear any gold or embroidered apparel, unless she proposed to be a common strumpet ; and that men should not wear rings or tissues except when they went a whoring, &c.

Among the Romans, the sumptuary laws were very numerous : By the *Lex Orchia*, the number of guests at feasts was limited, though without any limitation of the charges : by the Fannian law, made 22 years afterwards, it was enacted, that more than 10 *asses* should not be spent at any ordinary feast : for the solemn feasts, as the Saturnalia, &c. an hundred asses were allowed ; ten of which, Gellius informs us, was the price of a sheep, and a hundred of an ox. By the Didian law, which was preferred 18 years after, it was decreed, that the former sumptuary laws should be in force, not only in Rome, but throughout all Italy ; and that for every transgression, not only the master of the feast, but all the guests too, should be liable to the penalty.

The English have had their share of sumptuary laws, chiefly made in the reigns of Edw. III. Edw. IV. and Henry VIII. against shoes with long points, short doublets, and long coats ; though all repealed by statute 1 Jac. I. c. 25. As to excess in diet, there remains still one law unrepealed. Under King Henry IV. Camden tells us, pride was got so much into the foot, that it was proclaimed, that no man should wear shoes above six inches broad at the toes. And their other garments were so short, that it was enacted, 25 Edw. IV. that no person, under the condition of a lord, should, from that time, wear any mantle or gown, unless of such length, that, standing upright, it might cover his privy members and buttocks.

SUN, SOL, ☉, in astronomy, the great luminary which enlightens the world, and by its presence constitutes day. See ASTRONOMY-Index.

Mock-SUN. See PARHELION.

SUN-Fish of the Irish. See SQUALUS.

SUN-Flower, in botany. See HELIANTHUS.

SUN-Dew, in botany. See DROSER.

SUNDA-ISLANDS, a general name for a cluster of islands in the India Ocean, between 93° and 120° of east longitude, and between 8° north and 8° south latitude. The particular names of the islands are *Borneo*, *Sumatra*, *Java*, *Bally*, *Banca*, &c.

SUNDAY, or the LORD'S-DAY, a solemn festival observed by Christians on the first day of every week, in memory of our Saviour's resurrection. See SABBATH.

In the breviary and other offices we meet with Sundays of the first and second class. Those of the first class are, Palm, Easter, Advent, and Whitsunday, those of *Quasimodo* and *Quadragesima*. Those of the second class are the common Sundays. Anciently each Sunday in the year had its particular name, which was taken from the introit of the day ; which custom has only been continued to some few in lent ; as *Reminiscere*, *Oculi*, *Letare*, *Judica*.

Some are of opinion that the Lord's-day, mentioned in the Apocalypse, is our Sunday ; which they believe was so early instituted by the apostles. Be this as it will, it is certain a regard was had to this day even in the earliest ages of the church ; as appears from the first apology of Justin Martyr, where he describes the exercise of the day not much unlike to ours.

But it was Constantine the Great who first made a law for the proper observation of Sunday ; and who, according to Eusebius, appointed it should be regularly celebrated throughout the Roman empire. Before him, and even in his time, they observed the Jewish Sabbath as well as Sunday ; both

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to satisfy the law of Moses and to imitate the apostles, who used to meet together on the first day.

By Constantine's laws, made in 321, it was decreed, that for the future the Sunday should be kept a day of rest in all cities and towns ; but he allowed the country people to follow their work. In 538, the council of Orleans prohibited country labour ; but because there were still many Jews in Gaul, and the people fell into many superstitious usages in the celebration of the new Sabbath, like those of the Jews among that of the old, the council declares, that to hold it unlawful to travel with horses, cattle, and carriages, to prepare food, or to do any thing necessary to the cleanliness and decency of houses or persons, favours more of Judaism than of Christianity. See SABBATH-Breaking.

SUNDAY-Schools. See Sunday-SCHOOLS.

SUOVETAURILIA, an ancient Roman sacrifice, so called because it consisted of a pig (*sus*), a sheep or rather ram (*ovis*), and a bull (*taurus*). They were all males, to denote the masculine courage of the Roman people. It was likewise called *solitaurilia*, because the animals offered up were always *solida*, whole or uncut.

SUPERCARGO, a person employed by merchants to go a voyage, and oversee their cargo or lading, and dispose of it to the best advantage.

SUPERCILIUM, in anatomy, the eye-brow. See ANATOMY, n° 142.

SUPEREROGATION, in theology, what a man does beyond his duty, or more than he is commanded to do. The Romanists stand up strenuously for works of supererogation, and maintain that the observance of evangelical councils is such. By means hereof, a stock of merit is laid up, which the church has the disposal of, and which she distributes in indulgences to such as need.

This absurd doctrine was first invented towards the close of the 12th century, and modified and embellished by St Thomas in the 13th : according to which, it was pretended that there actually existed an immense treasure of merit, composed of the pious deeds and virtuous actions which the saints had performed beyond what was necessary for their own salvation, and which were therefore applicable to the benefit of others ; that the guardian and dispenser of this precious treasure was the Roman pontiff ; and that of consequence he was empowered to assign to such as he thought proper a portion of this inexhaustible source of merit, suitable to their respective guilt, and sufficient to deliver them from the punishment due to their crimes.

The reformed church do not allow of any work of supererogation ; but hold with the apostles, that when we have done our best, we are but unprofitable servants.

SUPERFETATION, in medicine, a second or after-conception, happening when the mother, already pregnant, conceives of a latter coition ; so that she bears at once two fetuses of unequal age and bulk, and is delivered of them at different times. We meet with instances of superfetations in Hippocrates, Aristotle, Du Laurens, &c. : but they are said to be much more frequent in hares and swine.

SUPERFICIES, or SURFACE, in geometry, the outside or exterior face of any body. This is considered as having the two dimensions of length and breadth only, but no thickness ; and therefore it makes no part of the substance or solid content or matter of the body.

The terms, or bounds, or extremities, of a superficies, are lines ; and superficies may be considered as generated by the motions of lines. Superficies are either rectilinear, curvilinear, plane, concave, or convex. A rectilinear superficies is that which is bounded by right lines. Curvilinear superficies

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superficies.

Superfine
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Supersti-
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cies is bounded by curve lines. Plane superficies is that which has no inequality in it, nor risings, nor sinkings, but lies evenly and straight throughout, so that a right line may wholly coincide with it in all parts and directions. Convex superficies is that which is curved and rises outwards. Concave superficies is curved and sinks inward. See GEOMETRY.

SUPERFINE, in the manufactories, a term used to express the superlative fineness of a stuff: thus a cloth, a camblet, &c. are said to be superfine when made of the finest wool, &c. or when they are the finest that can be made.

SUPERFLUOUS INTERVAL, in music, is one that exceeds a true diatonic interval by a semitone minor. See INTERVAL.

SUPERINTENDANT, denotes an ecclesiastical superior in several reformed churches where episcopacy is not admitted; particularly among the Lutherans in Germany, and the Calvinists in some other places.

The superintendent is similar to a bishop; only his power is somewhat more restrained than that of our diocesan bishops. He is the chief pastor, and has the direction of all the inferior pastors within his district or diocese. In Germany they had formerly superintendents general, who were superior to the ordinary superintendents. These, in reality, were archbishops; but the dignity is sunk into disuse; and at present none but the superintendent of Wirtemberg assumes the quality of superintendent general.

SUPERIOR, a person raised above another in rank, office, or talents.

SUPERIOR, in Scots law. See LAW, N^o clxiv. 3. clxv. 2. & clxvi.

SUPERLATIVE, in grammar, one of the three degrees of comparison, being that inflection of adjective nouns that serves to augment and heighten their signification, and shows the quality of the thing denoted to be in the highest degree. See GRAMMAR.

SUPERNUMERARY, something over and above a fixed number. In several of the offices are supernumerary clerks, to be ready on extraordinary occasions.

SUPERPARTICULAR PROPORTION, or *Ratio*, is that in which the greater term exceeds the less by unit or 1. As the ratio of 1 to 2, or 2 to 3, or 3 to 4, &c.

SUPERPARTIENT PROPORTION, or *Ratio*, is when the greater term contains the less term once, and leaves some number greater than 1 remaining. As the ratio

of 3 to 5, which is equal to that of 1 to $1\frac{2}{3}$;

of 7 to 10, which is equal to that of 1 to $1\frac{3}{7}$, &c.

SUPERSEDEAS, in law, a writ issued in divers cases, importing in general a command to stay or forbear some ordinary proceedings in law, which in appearance ought to be done or pursued, were it not for the cause whereon this writ is granted.

Thus a man regularly is to have a surety of peace against him of whom he will swear he is afraid; and the justice required hereunto cannot deny it him: yet, if the party be formerly bound to the peace, either in chancery or elsewhere, this writ lies to stay the justice from doing that which otherwise he ought not to deny.

SUPERSTITION, a word that has been used so indefinitely, that it is difficult to determine its precise meaning. From its resemblance in sound to the Latin word *superstes*, "a survivor," it is evidently derived from it, and different attempts have been made to trace their connection in signification. Balbus, in the dialogue *De Natura Deorum* of Cicero, says, that they who prayed and sacrificed whole days that their children might survive them, were called superstitious. Lactantius censures this etymology, and says

they were not called superstitious who wished that their children might survive them (for this we all wish), but because they who survived their parents worshipped their images. Others again say, that superstition is derived from *superstes*, because it consisted in considering the dead as if they were alive. But these etymologies are solely conjectural; and we consider conjectures as absurd in philology as we do in science; they may mislead, but are seldom of any benefit. The usual meaning affixed to the word *superstition*, both in the Latin and English languages, is so different from *superstes*, that its change of meaning must be owing to some accident which it is in vain to inquire after. If we had not known that the word *paganus* "a pagan" was derived from *pagus* "a village," because the heathens in a certain period of the Christian history lived in villages, the whims and fancies of etymologists would not have thrown much light on the subject.

Without labouring, from the aid of etymology, to define superstition, which is a word of a very extensive signification, we will consider to what objects it is applied; and then, by observing what is common to them all, we shall be enabled to fix with some degree of precision the meaning of the term. We apply it to the idolatry of the heathens; we apply it also to the Jews, who made the will of God of no effect by their traditions, and substituted ceremonies in place of the religion of their fathers. We say also that Christians are guilty of superstition; the Roman Catholics, who believe in transubstantiation and in the efficacy of prayers to saints; and those Protestants who esteem baptism and the Lord's supper, and the punctual performance of other ceremonies, without regard to morality, as sufficient to ensure salvation. Those persons also are reckoned superstitious who believe, without any evidence, that prophecies are still uttered by the divine inspiration, and that miracles are still performed. The word is also extended to those who believe in witchcraft, magic, and apparitions, or that the divine will is declared by omens or augury; that the fortune of individuals can be affected by things indifferent, by things deemed lucky or unlucky, or that diseases can be cured by words, charms, and incantations.

Through all the particulars which we have enumerated, there runs one general idea, the belief of what is false and contrary to reason. From this, however, we must not suppose that whatever is false and contrary to reason may be denominated superstition. We think that it is false and irrational to suppose that there ever lived on earth a race of men who walked on one leg, and had their eyes in their breast; or that there were giants 90 feet high: yet we do not call the philosopher who believes these chimeras superstitious, but credulous. Superstition has always a reference to God, to religion, or to beings superior to man. We do not however distinguish all false and irrational opinions in religion by the name of superstition. We do not, for instance, apply this name to the opinions which some of the ancients entertained, that God is the soul of the world, and that men are only portions of him separated for a time, or that the soul after death lives successively in different bodies. If we examine the subject with more attention, we shall discover that the foundation of superstition is ignorance of the moral attributes of God; for we never say a man is superstitious for entertaining erroneous opinions of the natural attributes of God. Some of the Socinians have denied the prescience of God; and a French philosopher has not only rejected the belief that He is a spirit, but has presumed to say that he is composed of a species of crystals. The first of these opinions discovers very imperfect ideas of God, and the second is the height of impiety and absurdity; yet the

Supersti-
tion.

Superstition. Socinians have not been accused of superstition, nor can this French philosopher be suspected of it. We do not call every false opinion concerning the unity or moral attributes of God by the name of superstition, as, for instance, the opinion which some sceptics have supported, that God is not good; for, as was mentioned before, superstition always involves the idea of credulity. It does not consist in falsely denying that God possesses any particular moral attributes, but in believing more than what is true concerning them; in forming mean, unworthy ideas of them; in supposing that he is guided by blind passion like mankind, and enjoins upon his creatures commandments which are irrational and absurd.

As superstition arises from ignorance and credulity in the understanding, so it has also a seat in the passions. Fear has been commonly considered as the passion of the human mind from which it chiefly derives its origin; and there is no doubt that more superstition has arisen from fear united with ignorance and credulity than from any other passion. Yet it would certainly be improper to exclude all other passions. We cannot account for the superstition of the Egyptians, without supposing that much of it arose from gratitude. They worshipped the Nile, because it distributed fertility and abundance over the land of Egypt; and they worshipped some animals, merely because they prevented the increase of other animals which were noxious. Thus they adored the ibis, because it destroyed the eggs of the crocodile.

Having thus endeavoured to analyze the ideas comprehended under the word superstition, we may sum them up in a few words. It respects God and beings superior to man, and extends to our religious opinions, worship, and practices; and may be defined *absurd opinions and actions arising from mean and defective ideas of the moral attributes of God*. Let us apply this definition to the different species of superstition already mentioned.

But before entering upon this application, it may be proper to observe, that superstition involves the idea of a blameable inattention to reason, or a credulity arising from an indolence of understanding. We generally make a distinction between the imperfect opinions which a savage, from the necessary effects of his situation, forms of the attributes of God, and those which civilized nations entertain. We say the savage is ignorant, and we ascribe his ignorance to his situation; but we call the Roman Catholic superstitious, and we blame him for not having those just ideas of God which he might have obtained by opening his Bible, or by the exercise of his understanding in the favourable situation in which he is placed. Superstition then does not originate so much from the natural weakness of the human understanding, as from a misapplication or a neglect of it (A).

Theophrastus's Characters, lvi. We cannot therefore with any propriety apply the name *superstition* to polytheism in general; for what all the ancient philosophers, after much study and reflection, concluded to be true, could never proceed from credulity and inattention, but from their situation. We speak very properly, however, when we call idolatry by the name of superstition; because there is no man so devoid of understanding as not to be capable of discovering, that a piece of metal, or wood, or stone, can neither hear nor answer petitions. *Superstition* was a name which the ancient philosophers gave to those who entertained mean opinions of the gods, or did foolish things to obtain their favour. According to Theophrastus, the superstitious man is one who, having washed his hands, and sprinkled himself all round, leaves the temple with a laurel leaf in his mouth, with which he walks about the whole day. Or, if a weasel should cross the road, he will not advance a step till he has thrown three stones over the road. If he finds

Superstition. a serpent in his house, he rears a place of devotion on the spot. He purifies his house often, will not sit upon a grave, nor touch a dead person. He is anxious about the interpretation of his dreams, will not offer a sacrifice unless his wife go along with him, or, if she is engaged, he takes the nurse and the little children. He purifies himself with onions; and when he sees a mad or an epileptic person, he spits in their bosom. Such was the character of superstition in the days of Theophrastus. All these whimsical ceremonies were done to prevent mischief, and to avert the wrath of the gods; and therefore perfectly correspond with the definition given above.

It is only necessary to consider a little the superstitious opinions and practices among Jews and Christians, to be sensible that they have all arisen from mean and absurd ideas of the moral attributes of God; for they have generally entertained noble opinions of his natural attributes. The Jews considered God as a partial Being, who had a predilection for their nation in preference to all others, and preferred external homage and ceremony to moral purity. If the Roman Catholics think consistently, they must esteem God as a Being who can be prevailed upon by the importunity of one dead man to assist another, or as a Being whose patience would be fatigued with hearing prayers constantly. Hence their practice of praying to saints. They in effect believe, however they may deceive themselves, that God is unjust, or they could not believe transubstantiation; for it supposes that God can give commands directly contrary to those principles of belief with which he has endued the human mind. They consider a strict adherence to a variety of ceremonies, to forms, to pomp, and show, as essential to the worship of God: this is treating God as a vainglorious Being. They thought it their duty to extirpate heretics: this was supposing God a cruel and revengeful Being. Even among Protestants, we are sorry to say, a great deal of superstition remains: we have not yet learned to consider God as a spirit, who is to be worshiped in spirit and in truth, as a pure moral benevolent Being; and hence arises all the superstitious practices which prevail among us.

Besides those superstitious opinions and practices which entirely respect our duty to God, there are others which may be termed *vulgar superstitions*. These also arise from imperfect and mean ideas of the moral attributes of God. To believe vulgar prophecies, which are always the effusions of madness or knavery, is to suppose that God, who has drawn a veil over futurity, and only delivers prophecies to accomplish some great moral purpose, sometimes gives them for no purpose at all, or to gratify idle curiosity, or to disclose such a knowledge of what is to happen as is inconsistent with the free agency of man and the moral administration of the world. Nor is it less superstitious to believe in vulgar miracles. To believe in them, is to believe that God suspends the laws of nature for the most trivial purposes, or to countenance fraud and worldly ambition: it is to receive the most extraordinary facts upon the most unsatisfactory evidence. The belief of witchcraft, of apparitions, and the second sight, may be resolved into the same principle. To suppose that God would communicate the power of doing mischief, and of controuling his laws, to any being merely for gratifying their own passions, is unworthy of God. The belief of apparitions is equally inconsistent with the goodness of God (see SPECTRE). The same objection rises against the second sight as against the belief of vulgar prophecies, and may also be extended to omens, to astrology, to things lucky and unlucky, to fortune-telling, &c. As to the different devices and charms for preventing and curing disorders, they resemble in every respect false miracles.

(A) We do not pretend to say that this is the sense in which superstition is always used, because it is often used improperly.

Supersti-
tion.

A judicious history of superstition would be a curious and entertaining work, and would exhibit the human character in a remarkable point of view. Superstition is most prevalent among men of weak and uncultivated minds; it is more frequent in the female sex than among men; and abounds more in the rude than in the refined stages of society. The general features of it have been the same in all ages; but it assumes certain peculiarities according to the diversity of character of different nations. It gained admission into the science of medicine at an early period. He who was endowed with superior genius and knowledge was reckoned a magician. Dr Bartolo was seized by the inquisition at Rome in the last century, because he unexpectedly cured a nobleman of the gout. Diseases were imputed to fascination, and hundreds of poor wretches were dragged to the stake for being accessory to them. Mercatus, physician to Philip II. of Spain, a writer of uncommon accuracy and information, appears strongly inclined to deny the existence of fascinator diseases: but he is constrained to acknowledge them for two reasons; 1st, Because the inquisition had decided in favour of their reality; 2^{dly}, Because he had seen a very beautiful woman break a steel-mirror to pieces, and blast some trees by a single glance of her eyes.

Manchester
Transactions,
vol. iii.

As the opinions concerning the cause of diseases were superstitious, those concerning the method of curing them were not less so. In the *Odyssey* we read of a cure performed by a song. Josephus relates, that he saw a certain Jew, named *Eleazar*, draw the devil out of an old woman's nostrils by the application of Solomon's seal to her nose in presence of the Emperor Vespasian. Many different kinds of applications were used for expelling the devil. Flagellation sometimes succeeded admirably; purgatives and antispasmodics were other modes of discharging him. Dr Mynfight cured several bewitched persons with a plaster of assafœtida. How the assafœtida was so efficacious, was much disputed. Some thought the devil might consider so vile an application as an insult, and run off in a passion; but others very sagely observed, that as devils are supposed to have eyes and ears, it is probable they may have noses too.

Nor was it only in medicine these superstitious opinions were entertained; they prevailed also in natural philosophy. The pernicious effects in mines, which we now know are occasioned by noxious air, were confidently imputed to the demons of the mine. Even Van Helmont, Bodinus, Strozza, and Luther, attributed thunder and meteors to the devil. Chemists were employed for centuries in search of the philosopher's stone, with which they were to do miracles. It was a common question among philosophers in the last century, whether the imagination could move external objects? A question generally decided in the affirmative.

Though superstition be generally the mark of a weak mind, such is the infirmity of human nature, that we find many instances of it among men of the most sublime genius and most enlightened minds. Socrates believed that he was guided by a demon. Lord Bacon believed in witchcraft; and relates that he was cured of warts by rubbing them with a piece of lard with the skin on, and then nailing it with the fat towards the sun on the post of a chamber window facing the sun. Henry IV. one of the most illustrious of monarchs, was very uneasy before his as-

Memoirs
of Sully.

Ibid.

Bayle,
Art. Mo-
vin.

fascination on account of some prophecies*. Sully declares, that one of the considerations that kept him faithful to his master in the most unpromising state of his affairs, was a prediction of La Brosse, that Henry would make his fortune†. The astrologer Morin directed Cardinal Richelieu's motions in some of his journeys‡. The enlightened Cudworth defended prophecies in general, and called those who opposed the belief of witchcraft by the

name of *atheists*; and the predictions of Rice Evans have been supported in the present century by the celebrated names of *Warburton* and *Fortin*. Dr Hoffman, the father of the Modern Theory and Practice of Medicine, in a dissertation published in the large edition of his works in 1747, says, that the devil can raise storms, produce insects, and act upon the animal spirits and imagination; and, in fine, that he is an *excellent optician and natural philosopher* on account of his long experience. Dr Johnson, the leviathan of literature, is supposed to have believed the second sight.

Supervisor
||
Supper.

With respect to the effects of superstition on the human mind, they are indeed deplorable. It chains down the understanding, and sinks it into the most abject and sordid state, and keeps it under the dominion of fear, and sometimes of cruelty. Where once it takes possession, it has a tendency to become extreme, and generally becomes so intolerable, that men of reflection and learning conspire its destruction. The Christian religion gave a violent shock to the heathen superstition; the reformation in a great measure demolished the superstition of the church of Rome; and the superstition which remained among Protestants after their separation from that church has been gradually yielding to the influence of enlightened reason, or to the bold and daring attacks of infidelity and deism. We behold the prospect of its ruins with pleasure, and thank the deists for their zeal; but it is from the firm hope that the religion of Jesus will arise in all its beauty and simple majesty, and be admired and respected as it deserves: for mean and contemptible as superstition certainly is, we would rather see men do what they reckon their duty from superstitious principles, than see anarchy and vice prevail, even though attended with all the knowledge and liberality of sentiment which deism and infidelity can inspire.

SUPERVISOR, a surveyor or overseer.

SUPINATION, in anatomy, the action of a supinator muscle, or the motion whereby it turns the hand so as that the palm is lifted up towards heaven.

SUPINE, in Latin grammar, part of the conjugation of a verb, being a verbal substantive of the singular number and the fourth declension.

There are two kinds of supines: One, called the *first supine*, ending in *um* of the accusative case, which is always of an active signification, and follows a verb of motion; as *abiit deambulatum*. The other, called the *last supine*, and ending in *u* of the ablative case, is of a passive signification, and is governed by substantives or adjectives; as, *facile dictu*, &c.

They have their name, says Probus, and after him Vossius, *quod ad instar supinorum & otiosorum hominum omnia habent confusa*: or, according to Priscian, *quod nascantur a participiis passivis, quæ supina appellata sunt, quia in infimo loco sita, totam conjugationis molem suscipiant*.

SUPPER, the evening repast.—Suppers that are heavy should be avoided, because the stomach is more oppressed with the same quantity of food in an horizontal posture than in an erect one, and because digestion goes on more slowly when we sleep than when we are awake. They should be eaten long enough before bed-time, that they may be nearly digested before going to sleep; and then a draught of pure water will dilute that which remains in the stomach.

SUPPER of the Lord, otherwise called the *Eucharist*, is a sacrament ordained by Christ in his church, of which the outward part is bread and wine, and the inward part or thing signified the body and blood of Christ, which the majority of Christians believe to be in some sense or other taken and received by the faithful communicants. See SACRAMENT.

There is no ordinance of the gospel which has been the subject of more violent controversies between different churches, and even between different divines of the same church,

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* Exod.
xii. 15, 19.

† In Miss.
nam.

‡ Hom. 12.
in Hieremum.

That it was unleavened bread which our Lord blessed and brake and gave to his disciples as his body, cannot be questioned; for at the time of the passover, when this ordinance was instituted, there was no leavened bread to be found in Jerusalem*. For the mixed cup, the evidence is not so decisive. It is indeed true, as we have observed under the article EUCHARIST, that the primitive Christians used wine diluted with water; and if we may believe Maimonides†, it was the general custom of the Jews, as well at the passover as at their ordinary meals, to add a little water to their wine on account of its great strength; but that this was *always* done, or that it was done by our Saviour in particular, there is no clear evidence. Origen indeed affirms‡, that our Lord administered in wine unmixed; and he was not a man to hazard such an affirmation, had there been in his days any certain tradition, or so much as a general opinion, to the contrary. On this account we have often heard with wonder the necessity of the mixed cup insisted on by those who without hesitation make use of leavened bread; for if it be essential to the sacrament that the very same elements be employed by us that were employed by our Saviour, the necessity of unleavened bread is certainly equal to that of wine diluted by water.

But the mixed cup is said to be emblematical of the blood and water which flowed from the side of our Lord when pierced by the spear of the Roman soldier, while the absence of leaven is emblematical of no particular circumstance in His passion. This argument for the mixture is as old as the era of St Cyprian, and has since been frequently urged with triumph by those who surely perceived not its weakness. The flowing of the blood and water from our Saviour's side was the consequence either of the spear's having pierced the *pericardium*, or more probably of an *ascites* or *hydrothorax*, occasioned by his cruel and lingering death (see MEDICINE, n° 342, 343.) But whatever was the cause of it, how can the mixing of wine with water in the sacrament be emblematical of the flowing of

blood and water separately? Such a mixture surely bears a more striking resemblance to the reunion of the *serum* and *crassamentum*, after they had been separated by whatever cause. See BLOOD.

We urge not these objections to the mixed cup from any dislike that we have to the practice. It is unquestionably harmless and primitive; and we wish that greater regard were paid to primitive practices than the generality of Christians seem to think they can claim: but let the advocates for antiquity be consistent; let them either restore, together with the mixed cup, the use of unleavened bread, or acknowledge that neither the one nor the other is essential to the sacrament. This last acknowledgment must indeed be made, if they would not involve themselves in difficulties from which they cannot be extricated. If either the mixed cup or unleavened bread be absolutely necessary to the validity of the sacrament, why not wine made from the grapes of Judæa? why not that particular kind of wine which was used by our Saviour? and where is that wine to be found?

But the controversies respecting the outward part or sign of the Lord's Supper are of little importance when compared with those which have been agitated respecting the inward part or thing signified; and of these we hasten to give as comprehensive a view as the limits prescribed to such articles will admit.

Our Blessed Lord, in the same night that he was betrayed, "took bread, and blessed it, and brake it, and gave it to the disciples, and said, Take, eat; this is my body. And he took the cup, and gave thanks, and gave it to them, saying, Drink ye all of it; for this is my blood of the new testament, which is shed for many for the remission of sins." Such was the institution of the Lord's Supper as it is recorded in the gospel by St Matthew; and we have the same account of it, in almost the very same words, by three other inspired writers, St Paul, St Mark, and St Luke. That it was the bread which Christ blessed and brake that is here called his body, and the wine over which he gave thanks that he styles his blood of the new testament, will admit of no reasonable doubt (A); but in what sense they became so, has been the subject of many controversies.

The church of Rome, which holds, that after consecration, Jesus Christ, God and man, is really, truly, and substantially, contained under the outward appearances of the bread and wine, informs us, that about the middle of the mass, when the priest, taking into his hand, first the bread and then the wine, pronounces over each separately the sacred words of consecration, the substance of these elements is immediately changed by the almighty power of God into the body and blood of Christ; but that all the outward appearances of the bread and wine, and all their

(A) Some over-zealous Protestants have indeed affirmed, that it was not the consecrated bread and wine, but those elements, together with the whole action of taking them into his hands, blessing them, breaking the bread, and distributing the bread and wine to the disciples, that Christ calls his body and blood. This novel and singular opinion rests upon no better foundation than a very childish criticism. Our Saviour, after blessing and breaking the bread, gave it to the disciples, saying, in the original, *λαβετε, φάγετε ΤΟΥΤΟ ὅτι τὸ σῶμα μου*. Now, say our critics, *τοῦτο*, in the neuter gender, can never agree with the antecedent *ἄρτος* in the masculine, but must refer to all the circumstances of the action taken together, and considered as one complex neuter noun. But this noun, whether complex or simple, certainly denotes what could be eaten; and to suppose that our blessed Lord desired his apostles to eat *actions*, is as repugnant to human reason as any doctrine of the church of Rome. The truth is, that the word *τοῦτο*, which is more properly a definite article than a demonstrative pronoun (see GRAMMAR, Chap. II.), refers directly to the thing, whatever it was, which our Saviour held in his hand and gave to the disciples; and the clause, when completed, is *τοῦτον ὅτι τὸ σῶμα μου*; this being, this substance, is my body. There was no necessity for characterising that substance by any analogy to sex, in order that it might be distinguished from every other substance; for the apostles could not but see it in the hand of their Master.

Supper. sensible qualities remain. This more than miraculous change is called **TRANSUBSTANTIATION**; and is founded on the philosophy of Aristotle, which resolves all bodies into *matter* and *form* (see **METAPHYSICS**, n^o 142—150.); for it is only the *matter* or imperceptible substance which supports the *forms* or sensible qualities of bread and wine, that is changed into the *substance* or matter of the body and blood of Christ, so that this divine matter, coming into the place of the former earthly matter, supports the same identical *forms* which it supported. Hence we are told, “that Jesus Christ, now present instead of the bread and wine, exhibits himself to us under those very same outward *forms* or appearances which the bread and wine had before the change.”

Could this doctrine be true, it would be abundantly mysterious; but to add to the mystery, we are farther informed, that under each kind is contained Jesus Christ whole and entire, his body and blood, his soul and divinity; so that when a man eats what has the appearance of a wafer, he really and truly eats the body and blood, the soul and divinity, of Jesus Christ; and when he afterwards drinks what has the appearance of wine, he drinks the very same body and blood, soul and divinity, which not a minute perhaps before he had wholly and entirely eaten! The ingenious author from whose work we have taken this account of the Romish doctrine concerning the real presence, may perhaps reject our inference that the orthodox members of his church must believe the *soul* and *divinity* of Christ to be *eaten* and *drunk* in the Lord's Supper; but he cannot deny that, according to his statement of the Catholic faith, the soul and divinity are both received whole and entire into the stomach of each communicant. He says indeed, that “communion consists in receiving Jesus Christ whole and entire, his sacred body, his precious blood, his blessed soul, and his adorable divinity, into our *souls*;” but that which was formerly bread and wine unquestionably goes into the *stomachs* of the communicants; and since, according to him, it is now the body and blood of Christ, the soul and divinity must go thither with it, for these four cannot be separated. This our author himself grants. “The Scripture (says he) positively declares, that *Christ rising again from the dead, dieth no more; death shall no more have dominion over him* (Rom. vi. 9.) Consequently his body, his blood, and his soul, shall never more be separated from one another; and as the union of his divine and human natures can never more be broken, so neither can these, his two natures, united in his divine person, be ever separated. From this it necessarily follows, that wherever the body of Christ is, there also his blood, his soul, and his divinity, must of necessity be in like manner.”

Now, whether we suppose, with our author, that the soul and divinity of Christ directly carry his body and blood with them into the human soul, or, trusting in some degree to the evidence of sense, believe that the body and blood carry the soul and divinity with them directly into

the stomach of each communicant—is it credible, is it possible, that the high and lofty One, who inhabiteth eternity, and whom the oracles of truth assure us that even the heaven of heavens cannot contain, should be *substantially* received *whole* and *entire* into a finite spirit like the human soul, or into a body so limited as the human stomach? Our author says it is; declaring that, “by the blessed *presence* of Jesus Christ, *whole and entire within us*, are communicated to our souls all the heavenly graces which are the effects of the holy communion: such as the sanctification of the soul by an increase of justifying grace; the rendering of it more pure, more holy, more beautiful, more agreeable, in the eyes of God; the cleansing of the soul from all those venial sins and imperfections of which we repent, and preserving us from falling into mortal sins; the uniting of us in a most intimate manner with Jesus Christ, who comes to us in this holy sacrament on purpose to dwell in our souls and abide with us; and the giving us a pledge and earnest of a glorious immortality, to the enjoyment of which it brings us at last, if we persevere to the end in the grace of God.”

The consequence of the doctrine of transubstantiation is the *sacrifice of the mass*, by which, it is said, God's acceptance of Christ's sacrifice on the cross is obtained for the actual benefit of those persons in particular for whom the mass is offered. In the work so often quoted, we are told, that “Jesus Christ our redeemer, who is both our high-priest and our victim, who, in order to perfect the work of our redemption, and reconcile man with his offended Creator, offered himself once in a bloody manner upon the cross, in order to communicate and apply to the souls of individuals those graces, which, by his death, he merited for mankind in general, continues to offer himself daily upon the altar in an unbloody manner, by the ministry of his priests, in the *mass*. The sacrifice of the cross and that of the mass are both one and the same sacrifice, because in both the victim is the same and the high priest the same, viz. Jesus Christ. The only difference is in the *manner* of offering. On the cross he offered himself in a bloody manner and actually died; whereas on the altar he is offered up to God in an unbloody manner, not *actually* dead, but under the *appearance* of death;” so that the communicants not only eat the man Jesus Christ, but even eat him alive (B)!

It is known to all our readers that this doctrine of transubstantiation was one cause of the breach between the church of Rome and those various societies which call themselves reformed churches. The real and substantial change of the bread and wine into the body and blood of our Lord is rejected by every reformer as a change contradictory and impossible, and fraught with the most impious consequences; and volumes have been written to expose the weakness of those arguments which have so often been vainly urged in its support. It has been shown to imply numberless absurdities, such as, that the same thing can be in a million of different places, *whole* and *entire*, at the same time, ⁶ *implies numberless contradictions,*

(B) This whole account of the Romish doctrine respecting the sacrament of the Lord's Supper is taken from a work in two small volumes, called *The Sincere Christian instructed in the Faith of Christ, from the Written Word*. Its author is a man of learning, and great personal worth; and as he fills a high station in the church of Rome, we cannot doubt but that he has given a fair view of the doctrine of that church respecting this and every other article of which he treats. We are sorry however that his zeal should have impelled him, in a *popular* work, to write in the manner that he has done of the salvation of those who are not members of his church, or who cannot embrace all his opinions; for if his doctrine on this subject be implicitly received by those “over whom he has the rule, and for whose souls he is appointed to watch,” they must necessarily look upon the majority of their fellow-citizens as reprobates doomed to eternal perdition. Let this be our apology for treating some of those opinions, which he thinks so absolutely necessary

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the same instant of time; that it is near 1800 years old, and yet may be not more than one minute; that *forms* or sensible qualities are real things independent of their subject and the sentient beings who perceive them; that the infinite and eternal God, who created and sustains the universe, is himself wholly and substantially comprehended by the human soul; and that the half, or fourth, or tenth part of the body of Christ, is equal to the whole of that body. That these are necessary consequences of transubstantiation has been so completely proved in various works (c) to which every reader may have access, that it is needless for us to repeat arguments so hackneyed; but there are two objections to that doctrine, which, as we do not remember to have met with them elsewhere, and as they appear to us absolutely conclusive, it may be worth while to state in this place.

The advocates for the real presence in the Lord's Supper contend, that every word relating to that ordinance is to be taken in the strictest and most literal sense, and they affect to triumph over the Protestants, because their notions of the sacrament cannot be supported without having recourse to figure and metaphor. This however is a very vain triumph; for we hesitate not to affirm, that supposing transubstantiation possible, and even capable of proof, there is not in the whole New Testament a single word or a single phrase which, if interpreted *literally*, gives the slightest countenance to that wonderful doctrine. The reader will remember, that transubstantiation, as we have stated it from a dignitary of the Romish church, and as it is in fact stated by the council of Trent (p), consists in a change of the *matter, imperceptible substance, or substratum* of the bread and wine into the *matter, imperceptible substance, or substratum* of Christ's body and blood; for all parties agree that the sensible qualities of the bread and wine remain, and, according to the Romanist, are after consecration either supported by the *matter* of Christ's body and blood, or hung upon nothing. But the phrase *τοῦτο ἐστὶ τὸ σῶμα μου*, if taken in the literal sense, cannot possibly denote the consequence of such a change as this; for every person at all acquainted with the Greek language, especially the language of the Peripatetic school, knows that *τὸ σῶμα μου* signifies, not the *matter* or *substratum* of my body divested of its sensible qualities; but the body of me in its natural state, consisting of *matter* and *qualities*, or *matter* and *form* united. Unless therefore the *sensible qualities*, as well as the *matter* of the bread and wine, give place to the sensible *qualities* as well as the *matter* of our Saviour's body and blood, and unless he ap-

pear glorified on the altar as he appeared on the mount at his transfiguration, the words *τὸ σῶμα μου* must be interpreted figuratively. Had the apostles understood their Master's words in the sense in which they are understood by the church of Rome, they would have rendered them into Greek, not *τοῦτο ἐστὶ τὸ σῶμα μου*, "this is my *body*," but *τοῦτο ἐστὶ ἡ ὕλη τοῦ σώματος μου*, "this is the *matter* of my body." In like manner, when St John relates || that Jesus said, "Who- || so eateth my flesh and drinketh my blood, hath eternal life, and I will raise him up at the last day," had he understood his adorable Master to speak of his flesh and blood in the Eucharist in the sense in which they are taught to be there by the church of Rome, he would have represented him as saying, not *Ὁ τρώγων μου τὴν σάρκα, καὶ πίνων μου τὸ αἷμα*, but *Ὁ τρώγων τὴν ὕλην μου τῆς σαρκὸς, καὶ πίνων τὴν ὕλην μου τοῦ αἵματος*, "who so eateth the *matter* of my flesh, and drinketh the *matter* of my blood, hath eternal life, and I will raise him up at the last day."

But further, supposing this singular conversion possible in itself, it cannot be rendered credible, however stated in any language that ever was or ever will be spoken by man. At first sight it may appear paradoxical to affirm, that a possible fact cannot be so related as to obtain credit; but that transubstantiation, if possible, is such a fact, will be apparent on the slightest consideration.

The relation that subsists between things and words is arbitrary; so that what is termed *body* in English, is *σῶμα* in Greek, and *corpus* in Latin; and the same thing might with equal propriety (had the authors of these languages so pleased) have been expressed in the first by *soul*, in the second by *vous*, and in the third by *anima*. (See LANGUAGE, n^o 3, &c.) The consequences of this are, that there is no universal language spoken; that the natives of one country understand not the speech of those of another; and that different men speaking the same language are perpetually liable to mistake each other's meaning. Between the *substrata* of bodies and their *sensible qualities* there is a relation founded in nature, so that the sensible qualities which indicate the substance to which they belong, to be *gold*, for instance, in one country, indicate the same thing in every other country, and have done so from the beginning of time. The sensible appearances of bodies therefore are an universal language, the language of the Author of Nature, by which he declares to his creature man, that though the *ὕλη πρώτη*, or primary matter of all bodies, may be the same kind of substance; yet the *ὕλη προσειχης* of one body, or the internal combination of its primary parts, differs from that of another;

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Chap. vi.
verse 54.8
And inca-
pable of
proof.Is contrary
to Scrip-
ture,

necessary to salvation, with less ceremony than perhaps we should have done, had he less positively pronounced our damnation for not having it in our power to embrace them. He is not indeed much less severe on the most virtuous heathens, though they never saw the New Testament, or heard the doctrines of his church preached. But perhaps this severity may be occasioned by the following question of Cicero: "Cum fruges, *Cererem*; vinum, *Liberum* dicimus, genere nos quidem sermonis utimur usitato: sed ECQUEM TAM AMENTEM esse putas, qui illud, quo vescatur, deum credat esse?" *De Natura Deorum*, Lib. 3. Cap. 16.

(c) Among other works on this subject, we may confidently recommend to the reader a small tract published by Dr Abernethy Drummond, about twenty years ago, in the form of *A Dialogue between Philalethes and Benevolus*. In that treatise, together with a defence of it, which were both printed for Balfour and Drummond, Edinburgh, the absurd consequences which we have mentioned are, by arguments unanswerable, proved to flow from the doctrine of transubstantiation; and the artful sophistry, by which a very acute genius endeavoured to keep these consequences out of sight, is detected and exposed on acknowledged principles of the soundest metaphysics.

(p) The canon of that council which establishes transubstantiation is thus translated by the author of *The Sincere Christian Instructed*: "If any man shall say, that in the blessed sacrament of the Eucharist the substance of the bread and wine remains along with the body and blood of our Lord Jesus Christ, and shall deny that wonderful and singular conversion of the whole substance of the bread into the body, and of the whole substance of the wine into the blood, the appearances of the bread and wine only remaining, which conversion the Catholic Church calls *transubstantiation*, let him be anathema."

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ther; that gold, for instance, has a different *substratum* or *basis* from iron, lead, or silver; that the internal organization or structure of the body of an ox is different from that of a horse; and that the *internal substance* or *substratum* which exhibits the appearances of bread and wine is different from that which supports the sensible qualities of flesh and blood (see METAPHYSICS, Part I. Chap. I. and Part II. Chap. I. and II.). Supposing therefore the doctrine of transubstantiation to be possible and even true, it would still be impossible, by any statement of it in human language, or by any argument urged in its support, to render that doctrine an object of rational belief; for if it be said that the words *τοῦτο ἐστὶ τὸ σῶμα μου* were spoken by a divine person, who could neither be deceived himself nor intend to deceive us, it may be replied, that the sensible appearances of bread and wine, which are confessed to remain, are likewise the language of a divine person, even of the Creator and Governor of heaven and earth; that this language addressed to the sight, the taste, the touch, and the smell, is equally intelligible to all nations; that since the creation of the world its meaning has never been mistaken by the scholar or the clown, the sage or the savage, except in this single instance of our Lord's flesh and blood exhibiting the sensible appearances of bread and wine; and that it is therefore infinitely more probable that the members of the church of Rome should mistake the meaning of the words *τοῦτο ἐστὶ τὸ σῶμα μου*, which, though spoken by Christ, are part of the language of men, and liable to all its ambiguities, than that all mankind should mistake the language of God himself, which is liable to no ambiguities, and which was never in any other instance misunderstood by a single individual. Should transubstantiation therefore be really true, its truth can never be proved or rendered probable, but by an immediate operation of the spirit of God on the mind of man; and he who is conscious of no such operation on his own mind, may rest assured that the Father of mercies, who knows whereof he is made, will never bring upon him, for his incredulity in this instance, any of the anathemas denounced by the church of Rome upon those who place implicit confidence in the universal language of Him who created them, in opposition to her figurative and contradictory interpretations of the written word. Of the transubstantiation of the elements a visible miracle would afford no proof. Had the water been changed into wine at the marriage in Cana of Galilee, for the express purpose of bearing testimony to this singular conversion, what must have been the consequence on the minds of those who witnessed that miracle? Nothing, we think, but scepticism or a distrust of their own faculties; for they would have had the very same evidence that *no* substantial change was wrought on the elements, as that the water was *actually* turned into wine.

Though the reformed churches unanimously reject the doctrine of transubstantiation, and of course the sacrifice of the mass, its inseparable consequence, they are far from being agreed among themselves respecting the nature of the Lord's Supper; and the notions of this ordinance entertained by some of them appear to us as untenable as any part of the doctrine of the church of Rome. The Lutherans believe, that the body and blood of Christ are really and substantially present with the bread and wine; that the body is really and truly eaten, and the blood really and truly drunk, by the communicants; and that whatever motion or action the bread has, the body has the same. According to them, therefore, the same sensible appearances are exhibited by two substances united in some inexplicable manner, which is neither a personal union, nor incorporation, nor the inclosure of the body within the bread; nor

does it last longer than while the sacrament is celebrating. This union is generally called *CONSUBSTANTIATION*; but they reject the term, contenting themselves with asserting the real presence, without presuming to define the mode by which the body and blood of Christ are united to the sacramental elements.

It would be superfluous to waste time in replying to this doctrine. Every reader sees that it implies the possibility of the same thing's being whole and entire in a million of places at one and the same instant of time, which has been so often urged as an unanswerable objection to the Romish doctrine; and it is fraught with this additional absurdity peculiar to itself, that two bodily substances may at once occupy the same place, which is directly contrary to our notions of solidity. It may be observed too, that whatever be the real sense of our Saviour's words, he says expressly, "This is my body"—this thing which I give you, and which you see and feel; whereas, had he meant what Luther and his followers teach, he would surely have said, "With this bread receive my body, with this cup receive my blood."

The notions of some of the early Calvinists respecting the Lord's Supper are very mysterious, and expressed in language of which we are not sure that we understand the meaning. In the year 1561 an attempt was made in France to bring the Catholics and Protestants to an uniformity of doctrine on this great topic of controversy; and deputies were appointed by both parties to meet at *Poissy*, and debate the question in a friendly manner. The principal managers on the side of the Catholics were the cardinals of *Lorraine* and *Tournon*; those on the side of the Protestants were *Beza* and *Peter Martyr*. After several meetings, disputes, and violent separations, the Protestant deputies declared their faith in the following words: "We confess, that Jesus Christ, in the Supper, does truly give and exhibit to us the substance of his body and blood by the efficacy of his Holy Spirit; and that we do receive and eat spiritually, and by faith, *that very body which was offered and immolated for us*, so as to be bone of his bone and flesh of his flesh, to the end that we may be enlivened thereby, and receive what is conducive to our salvation. And because faith, supported by the word of God, makes those things present, which it apprehends, and by that faith we do in deed and reality receive the true natural body and blood of Christ, by the power of the Holy Spirit; by this means, we confess and acknowledge the presence of his body and blood in the Supper." One of the Catholic delegates expressing his dislike of this last clause, the Protestant ministers gave the following explanation of their sentiments: "No distance of place can hinder us from communicating of the body and blood of Christ, for the Lord's Supper is a heavenly thing; and though on earth we receive with our mouths bread and wine, which are the true signs of his body and blood, yet by faith, and the efficacy of the Holy Ghost, our minds, which are fed with this food, *are rapt up into heaven*, and enjoy the presence of the body and blood; and that by this means it may be said that the body is truly joined to the bread, and the blood to the wine; but after the manner of a sacrament, and not at all according to place or natural position *."

If the reader can discover the precise meaning of these passages, his sagacity exceeds ours. That the Protestant deputies believed, or professed to believe, that the *natural* body and blood of Christ are by the faithful received in the Lord's Supper, is indeed evident; but their notions respecting the manner of this reception are very unintelligible, if not contradictory. In the former quotation, they confess that Christ's body and blood are really present

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10
Of the early Calvinists9
Doctrine of the Lutherans incredible.

S. Luther. Cogit. MS. 400. Gerhard in Loc. Theol. de Sacra Cena.

* Thuanus, lib. 28. See also Johnson's Unbloody Sacrifice, vol. 1.

11
Unintelligible

¹²
Of the churches of Britain.

^{Supper.} in the sacrament; that they are made present by faith (we suppose the faith of the communicants); and that the *very body* which was offered and immolated for us is eaten *spiritually* and by *faith*. In the latter quotation, they seem to say that Christ's body and blood are in heaven, at a great distance from the true signs of them; that on earth the communicants receive only these signs, which are bread and wine; but that, by faith and the efficacy of the Holy Spirit, their minds, during actual communion, are rapt up into heaven, where they enjoy the presence of the body and blood; and that by this means the body and blood are truly joined to the bread and wine through the medium of the mind of the communicant, which is at once present both to the sign and to the thing signified. To this mysterious doctrine it is needless to urge objections. Every man who is accustomed to think, and to use words with some determinate meaning, will at once perceive that the authors of this declaration must have had very confused notions of the subject, and have pleased themselves with sound instead of sense, satisfied that they could not be wrong if they did not symbolize with the Lutherans or the Council of Trent.

The churches of England and Scotland, in their established doctrines respecting the Lord's Supper, appear to be Calvinistical; but the compilers of the Thirty-nine Articles and of the Confession of Faith must have been much more rational divines than Beza and Peter Martyr. They agree in condemning the doctrine of transubstantiation as contrary to common sense, and not founded in the word of God; they teach, that to such as rightly, worthily, and with faith, receive the sacrament, the bread which we break is a partaking of the body of Christ, and the cup of blessing a partaking of the blood of Christ; and they add, that the body and blood of Christ are eaten and drunk, not corporally or carnally, but only after a heavenly and spiritual manner, by which the communicants are made partakers of all the benefits of his death*. In one important circumstance these two churches seem to differ. The Confession of Faith, as we understand it †, affirms, that in the Lord's Supper there is no sacrifice made at all. The thirty-first article of the church of England likewise condemns the Popish sacrifice of the mass as a *blasphemous fable* and *dangerous deceit*; but in the order for the administration of the Lord's Supper or Holy Communion, the celebrator "beseeches God most mercifully to accept the alms and oblations of the congregation," and again "to accept *their sacrifice of praise* and thanksgiving:" from which petitions many have inferred that, in the Lord's Supper, that church offers a commemorative and eucharistical sacrifice. This inference seems not to be wholly without foundation. In the order for the administration of the Lord's Supper, according to the form of the Book of Common Prayer set forth by act of parliament in the second and third years of king Edward the Sixth, the elements were solemnly offered to God as a sacrifice of praise and thanksgiving; and though the prayer containing that oblation was, at the review of the liturgy some years afterwards, removed from the prayer of consecration, to which it was originally joined, and placed where it now stands in the post communion service; yet the very act of parliament which authorized that alteration, calling king Edward's "a very godly order, agreeable to the word of God and the primitive church, and very comfortable to all good people desiring to live in Christian conversation."

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The English church, however, has not positively determined any thing respecting this great question; and whilst she condemns the doctrine of the real presence, with all its dangerous consequences, she allows her members to entertain very different notions of this holy ordinance, and to publish these notions to the world. Accordingly, many of her most eminent divines (E) have maintained that, in the celebration of the Lord's Supper, the elements of bread and wine are offered to God as a sacrifice commemorative of Christ's one sacrifice for the sins of the whole world; that these elements, though they undergo no substantial change, yet receive such a divine virtue by the descent of the Holy Ghost, as to convey to the worthy communicant all the benefits of Christ's passion; that they are therefore called his body and blood, because being, after their oblation, eaten and drunk in remembrance of Him, they supply the place of his body and blood in the feast upon his sacrifice; and that it is customary with our Saviour to give to any thing the name of another of which it completely supplies the place, as when he calls himself the *door** of the sheep, because there is no entrance into the church or kingdom of God but by faith in him. They observe, that the Eucharist's being commemorative, no more hinders it from being a proper sacrifice, than the typical and figurative sacrifices of the old law hindered them from being proper sacrifices: for as to be a type doth not destroy the nature and notion of a legal sacrifice, so to be representative and commemorative doth not destroy the nature of an evangelical sacrifice. To prove that, in the celebration of the Lord's Supper, there is a real sacrifice offered to God as well as a sacrament received by the communicants, they appeal to St Paul, who says expressly †, that "Christians have an altar, whereof they have no right to eat who serve the tabernacle," and who by contrasting the cup of the Lord with the cup of devils, and the table of the Lord with the table of devils ¶, teaches plainly, that those cups and those tables had the same specific nature. That the *table of devils* spoken of by the apostle was the Pagan altars, and the *cup of devils* the wine poured out in libations to the Pagan divinities, will admit of no dispute; and therefore, say the advocates for the eucharistical sacrifice, the table of the Lord must be the Christian altar, and the cup of the Lord the wine offered to God as the representative of the blood of Christ; otherwise there would not be that *absurdity* which the apostle supposes, in the same person drinking the cup of the Lord and the cup of devils, and partaking of the Lord's table and the table of devils. They observe farther, that in all the ancient liturgies extant there is a solemn form of oblation of the sacramental elements, and that all the Christian writers from the second century downwards treat of the Lord's Supper as a sacrifice as well as sacrificial feast, having indeed no value in itself, but acceptable to God as representing Christ's one sacrifice for the sins of the world. Our limits will not permit us to give even an abstract of their arguments; but the reader who shall attentively peruse *Johnson's unbloody Sacrifice and Altar unveiled and supported*, will discover that their notions are better founded than probably he supposes, and that they are totally irreconcilable with the doctrine of transubstantiation and the Popish sacrifice of the mass.

Other English divines of great learning, with the celebrated Hoadley bishop of Winchester at the head of them, contend strenuously that the Lord's Supper, so far from being

(E) The archbishops Laud and Wake; the bishops Poynt, Andrews, Bull, and Patrick; the Doctors Hickes, Grabe, and Brett; Messrs Bingham, Johnson, Mede, Wheatly, Scandaret, Bowyer, &c.

^{Supper.} being a sacrifice of any kind, is nothing more than bread and wine reverently eaten and drunk, in remembrance that Christ's body was broken and his blood shed in proof of his Father's and his own love to mankind; that nothing is essential to the sacrament but this remembrance, and a serious desire to honour and obey our Saviour as our head; that the sacrament might be celebrated without uttering one prayer or thanksgiving, merely by a society of Christians, whether small or great, jointly eating bread and drinking wine with a serious remembrance of Christ's death; that St Paul enjoins a man to examine himself before he eat of that bread and drink of that cup, not to discover what have been the sins of his past life in order to repent of them, but only that he may be sure of his remembering Christ's body broken and his blood shed; that, however, it is his duty in that as in every other instance of religious worship to resolve to obey from the heart every precept of the gospel, whether moral or positive; and that to partake worthily of the Lord's Supper is acceptable to God, because it is paying obedience to one of these precepts; but that no particular benefits or privileges are annexed to it more than to any other instance of duty. Bishop Hoadley acknowledges, that when St Paul says *, "The cup of blessing which we bless, is it not the communion of the blood of Christ? The bread which we break, is it not the communion of the body of Christ?" he has been supposed by many learned men to affirm, that all the benefits of Christ's passion are in the Lord's Supper conveyed to the worthy communicant; but this (says he) is an idea which the apostle could not have in his thoughts as at all proper for his argument. The Greek word *κοινωνία* and the English *communion* signify only a partaking of something in common with others of the same society; and the apostle's meaning (he says) can be nothing more, than that in the Lord's Supper we do not eat bread and drink wine as at an ordinary meal, but as memorials of the body and blood of Christ, in honour to him as the head of that body of which we are all members. That the word *κοινωνία* is not meant to denote any inward or spiritual part of the Lord's Supper, he thinks evident, because the same word is used with regard to the cup and the table of idols, where no spiritual part could be thought of, and in an argument which supposes an idol to be nothing §.

§ A Plain Account of the Nature and End of the Lord's Supper.

13 And others, a feast upon our Saviour's sacrifice.

To this view of the nature and end of the Lord's Supper, it must appear no small objection, that "he who eateth and drinketh unworthily is said to be *guilty of the body and blood of the Lord, and to eat and drink a judgment to himself, not discerning the Lord's body.*" No doubt it would be sinful to eat and drink a mere memorial of Christ's death without serious dispositions; but we cannot conceive how a little wandering of the thoughts, which is all the unworthiness which the author thinks there can be on such an occasion, should be a sin of so deep a dye as to be properly compared with the guilt of those who murdered the Lord of life. Other divines therefore, feeling the force of this and similar objections, steer a middle course between the mere memorialist and the advocate for a real sacrifice in the holy Eucharist, and insist that this rite, though no sacrifice itself, is yet a feast upon the one sacrifice offered by Christ and slain upon the cross. The most eminent patrons of this opinion have been Dr Cudworth, bishop Warburton, and the present bishop of Chester; and they support it by such arguments as the following: "In those ages of the world when victims made so great a part of the religion both of Jews and Gentiles, the sacrifice was always followed by a religious feasting on the thing offered; which was called the *feast upon, or after the*

sacrifice, and was supposed to convey to the partakers of it the benefits of the sacrifice. Now Jesus (say they), about to offer himself a sacrifice on the cross for our redemption, did, in conformity to general practice, institute the *last supper*, under the idea of a *feast after the sacrifice*; and the circumstances attending its institution were such, they think, that the apostles could not possibly mistake his meaning. It was just before his passion, and while he was eating the paschal supper, which was a Jewish *feast upon the sacrifice*, that our blessed Lord instituted this rite; and as it was his general custom to allude, in his actions and expressions, to what passed before his eyes, or presented itself to his observation, who can doubt, when, in the very form of celebration, we see all the marks of a *sacramental supper*, but that the divine institutor intended it should bear the same relation to his *sacrifice on the cross* which the *paschal supper* then celebrating bore to the oblation of the *paschal lamb*? If this was not his purpose, and if nothing more was intended than a general memorial of a dead benefactor, why was this instant of time preferred for the institution to all others throughout the course of his ministry, any one of which would have been equally commodious? Indeed any other time would have been more commodious for the institution of a mere memorial; for the paschal lamb and unleavened bread were certainly a sacrifice; and the words used by our Saviour, when he gave the bread and wine to the apostles, were such as must necessarily have led them to consider that bread and wine as bearing the same relation to his sacrifice that the paschal supper bore to the paschal sacrifice. At that Jewish feast, it was the custom of every father of a family to break the unleavened bread, and to give to every guest a portion, saying, "This is the bread of affliction, which our fathers did eat in the land of Egypt:" a custom which, we may be sure, that Christ, as father of his family, would religiously observe. The apostles knew well that they were not eating the identical bread which their fathers did eat in Egypt, but the feast upon the sacrifice then offered in commemoration of their redemption from Egyptian bondage; and therefore when they saw their Master after supper break the bread again and give it to each of them, with these remarkable words, "This is my body which is given for you, do this in remembrance of me," they must have concluded, that his meaning was to institute a rite which should to the end of the world bear the same relation to his sacrifice that the paschal supper bore to the sacrifice of the passover.

This inference, from the circumstances attending the institution, bishop Warburton thinks confirmed by St Paul's mode of arguing with the Corinthians, on their impiety and absurdity in partaking both of the Lord's table and the table of devils; for "what (says he) had the eaters of the sacrifices to do with the partakers of the bread and wine in the Lord's Supper, if the Lord's Supper was not a feast of the same kind with their feasts? If the three feasts, Jewish, Pagan, and Christian, had not one common nature, how could the apostle have inferred that this intercommunity was inconsistent? Ye CANNOT (says he) drink the cup of the Lord and the cup of devils; ye CANNOT be partakers of the Lord's table and the table of devils. For though there might be impiety in the promiscuous use of Pagan and Christian rites of any kind, yet the inconsistency arises from their having a common nature, and consequently, as they had opposite originals, from their destroying one another's effects in the very celebration. Sacrifices, and feasts upon sacrifices, were universally considered as *federal* rites; and therefore the Lord's table and the table of devils being both *federal* rites, the same man could no more

Supper,
Supple-
ment.

be partaker of both, than he could at once engage to serve both God and the devil. This is the apostle's argument to the wise men, to whom he appeals; and we see that it turns altogether upon this postulatam, that the Christian and Pagan feasts had the same specific nature, or were both feasts upon sacrifices. If this be admitted, it is easy to see why St Paul deemed those who ate and drank unworthily guilty of the body and blood of the Lord; for if the Lord's Supper be a feast upon his sacrifice, it must have been considered as the means of conveying to the communicants all the benefits of his death and passion; and the profanation of such a rite, by rendering his death ineffectual, might be fitly compared and justly equalled to the enormous guilt of those by whom his blood was shed." In reply to bishop Hoadley's remarks upon the word *κοινωνια*, his brother bishop observes, that "had the apostle meant what the learned writer makes him to mean, he would doubtless have said *κοινωνια υμων εις το σωμα*, 'your communion in the body—your eating it jointly.' St Paul (continues he) knew how to express himself properly, as appears from a passage in his epistle to the Philippians, where, professedly speaking of the joint participation of a blessing, he uses these words, *κοινωνια υμων εις το ευαγγελιον*, 'your communion in the gospel.' To the other remark, that no spiritual part could be thought of in the table of idols, because an idol is said by the apostle to be *nothing*, bishop Warburton replies, "that by St Paul the Gentiles are said to have sacrificed to devils, and those who ate of such sacrifices to have had communion with devils: now the *devil* (continues his Lordship) was in St Paul's opinion *something*." But the inference which the apostle draws from the acknowledged truth, that the cup of blessing which we bless is the communion of the blood of Christ, and the bread which we break the communion of the body of Christ, puts his meaning, our author thinks, beyond all doubt. He says†, that the partaking of one bread makes the receivers of *many* to become *one body*. A just inference, if this rite be of the nature of a *feast upon the sacrifice*; for then *the communion of the body and blood of Christ* unites the receivers into one body by an equal distribution of one common benefit. But if it be only a general commemoration of a deceased benefactor, it leaves the receivers as it found them, not *one body*, but *many separate professors* of one common faith.

† 1 Cor. x.
17.

16
The ordi-
nance not
generally
understood.

Thus have we given such a view as our limits would permit us to give, of the principal opinions that have been held respecting the nature and end of the Lord's Supper. It is an ordinance which seems not to be generally understood; though, being intended to show forth the Lord's death till he come, it is surely of sufficient importance to engage the attention of every serious Christian. The most considerable Protestant divines who have expressly written upon it are, Johnson in his *Unbloody Sacrifice*; Cudworth in his *Discourse concerning the true Nature of the Lord's Supper*; Hoadley in his *Plain Account*; and Warburton in his *Rational Account*. The notions of Cudworth and Warburton are the same, and perhaps they differ not so much from those of Johnson as many readers seem to imagine. At any rate, the arguments by which Warburton supports his doctrine must have some force, since it is said that Hoadley himself acknowledged they would be unanswerable, if it could be proved that the death of Christ was a real sacrifice.

SUPPLEMENT, in literature, an appendage to supply what is wanting in a book. Books of various kinds require such an appendage; but none so much as a dictionary of arts and sciences, which, from the progressive course of physical science, cannot be completed without it.

SUPPORTED, in heraldry, a term applied to the uppermost quarters of a shield when divided into several quarters, these seeming as it were supported or sustained by those below. The chief is said to be supported when it is of two colours, and the upper colour takes up two-thirds of it. In this case it is supported by the colour underneath.

Supple-
ment
||
Supralapsa-
rians.

SUPPORTERS, in heraldry, figures in an achievement placed by the side of the shield, and seeming to support or hold up the same. Supporters are chiefly figures of beasts: figures of human creatures for the like purpose are called *tenants*.

SUPPOSITION, in music, is when one of the parts dwells on a note, while another part makes two or more lesser notes equivalent to it, by conjoint degrees.

Supposition is defined by a late author the using of two successive notes, of the same value as to time; the one whereof, being a discord, supposes the other a concord.

The harmony, Mr Malcolm observes, is always to be full on the accented parts of the bar or measure; but, on the unaccented, discords may transiently pass, without any offence to the ear. This transient use of discords, followed by concords, make what we, after the French, call *supposition*.

Concords by supposition are those where the continued bass adds or supposes a new sound below the fundamental bass; whence such concords always exceed the extent of the octave. Of these concords there are three sorts, all which are concords of the seventh: the first, when the added sound is a third below the fundamental sound; such is the concord of the ninth: and if the concord of the ninth is formed by the mediant, added below the sensible concord in the minor mode, then the concord is called the *superfluous fifth*. The second kind is, when the supposed sound is a fifth below the fundamental sound, as in the concord of the fourth or eleventh; and if the concord is sensible, and the tonic be supposed, this concord is called the *superfluous seventh*. The third kind is that where the supposed sound is below a concord of the diminished seventh: if it is a fifth below, *i. e.* if the supposed sound be the mediant, the concord is called the concord of the *fourth* and *superfluous fifth*: if it is a seventh below, *i. e.* if the supposed sound be the tonic, the concord is called the *lesser sixth* and *superfluous seventh*.

SUPPOSITORY, a kind of medicated cone or ball, which is introduced into the anus for opening the belly.

It is usually composed of common honey, mixed up with either soap or oil, and formed into pieces of the length and thickness of the little finger, only pyramidal. To the composition is sometimes also added powder of scammony, euphorbium, colocynthis, salt, aloes, &c. according to the case of the patient.

The suppository was invented for the convenience of such as have an aversion to the taking of clysters; or to be used when the disease does not allow thereof.

SUPPRESSION, in medicine, is generally used to signify a retention of urine or of the menses.

SUPPURATION, the second way wherein an inflammation terminates; being a conversion of the inspissated blood and the first adjacent parts, as the vessels and fat into pus or matter; which disorder, when it has not yet found an opening, is generally called an *abscess*.

SUPRACOSTALES, in anatomy. See *Table of the Muscles* in ANATOMY.

SUPRALAPSARIANS, in theology, persons who hold that God, without any regard to the good or evil works of men, has resolved, by an eternal decree, *supra lapsum*, antecedently to any knowledge of the fall of Adam, and independently of it to save some and to damn others; or, in other words, that God intended to glorify his justice

Supraspi-
natus
||
Surat.

in the condemnation of some, as well as his mercy in the salvation of others; and for that purpose decreed that Adam should necessarily fall, and by that fall bring himself and all his offspring into a state of everlasting condemnation.

These are also called *antelapsaries*, and are opposed to sublapsaries and infralapsaries.

According to the supralapsarians, the object of predestination is, *homo creabilis et labilis*; and, according to the sublapsarians and infralapsarians, *homo creatus et lapsus*.

SUPRASPINATUS, in anatomy. See *Table of the Muscles* in ANATOMY.

SUPREMACY, the superiority or sovereignty of the king. See SOVEREIGNTY.

SUR, or SHUR (anc. geog.), a desert of Arabia Petræa, extending between Palestine and the Arabian Gulph; into which the Israelites, after marching through the Red Sea, first came (Exod. xv. 22.) Again (Numb. xxxiii. 8.), it is said, that from the sea they went three days journey into the Wilderness of Etham; whence some conclude that Etham and Shur are the same wilderness; or only differ as a part from the whole, Shur being the general name, and Etham that part of it lying nearest to the place of encampment of the same name. We know so little of the geography of these places that there is more room for disputation than for decision. As to the route which the Israelites followed in their passage through the Red Sea, Mr Bryant, we think, has given the most satisfactory account in his late work on the Plagues of Egypt.—Shur is now called *Coor del*.

SURAT, a city of Indostan, belonging to Britain, on the western coast of the peninsula, a little to the northward of Bombay, and about 16 miles up the river Tappee. It is but of modern date, and is a most remarkable instance of the power of trade to bring wealth and population to any spot where it can be brought to settle. Towards the middle of the last century this place was only the resort of a few merchants, who, under the shelter of an old insignificant castle, laid the first foundations of a city now almost as large and fully as populous as London within the walls, and containing many fine buildings of Indian architecture, which is partly Gentoos and partly Morisque. Those of the greatest note are so contrived, that the gateway is defensible against any sudden irruption of a few armed men. The private apartments lie backwards for the convenience of the women, of whom the Moors are remarkably jealous. They are fond of having one room, in the midst of which a fountain keeps playing, and which, by its noise, lulls them to sleep, and refreshes the room by its coolness; but thus a damp is produced, which would be very dangerous to Europeans. They have also generally a saloon with fountains playing in it, which, with the variegated flower-beds, in which they are very curious, makes a beautiful prospect. During the intense heats of summer they have country retirements a little way out of town, where they reside, or go in parties to amuse themselves. The streets are irregularly laid out; but have one property which renders it agreeable to walk in them, viz. that a competent width being left at bottom, the upper stories of the houses project over one another in such a manner, that people may with ease converse from them; by which means the street is agreeably shaded, at the same time that a proper ventilation is not impeded, but rather promoted. The shops, notwithstanding the vast trade carried on in this great and populous city, have a very mean appearance, owing to the dealers keeping their goods in warehouses, and selling by samples.

No place is better supplied with provisions than the city of Surat while its communication with the country remains open. Besides the unbounded importation, by which every

article is brought here in great abundance, the natural productions of the soil are excellent, though less cheap than in other parts of India, as at Bengal especially; yet in that place, though the cattle and poultry are bought originally at a very low rate, they turn out very dear by the time they are fed for the table. Here, however, all kinds of eatables may be had at a reasonable price, ready for immediate use, and as good as can be found anywhere. The wheat of Surat is famous all over India for its singular substance, whiteness, and taste; and its sallads and roots are likewise of an excellent quality. There are also many kinds of wild-fowl and other game to be had at an easy rate; but for wines and spirituous liquors they depend mostly on importation.

Surat was surrounded with a wall in a short time after it had assumed the form of a town. The fortification, however, was meant only to prevent the incursions of the Mah-rattas, who had twice pillaged it; so that the place was by no means capable of standing any regular siege. Even the castle appears but a poor defence, being mounted with cannon here and there, without any order, or without any thing like an attempt towards military architecture.

In this city, before the East India company became invested with the possession of Bombay, was the presidency of their affairs on the western coast. For this purpose they had a factory established there with great privileges by the Mogul government; and even after the presidency was established at Bombay, they continued a factory here at one of the best houses in the city; which yet not being spacious enough to contain their effects, they hired another at some distance from it, and nearer the water-side, which was called the new factory. In the mean time, the city flourished, and became the centre of all the Indian trade, being much more frequented for the sake of foreign merchandize than for either the natural productions or manufactures of the country, though they also made a considerable part of its commerce. In short, there was scarce any article of merchandize but what was to be found at all times in Surat, almost as readily as in London itself. While the Mogul government was in its vigour, there was such a show of justice kept up, as induced merchants of all religions and denominations to take up their residence in the city. The Gentoos especially resorted thither, in order to avoid the oppressions of their own government. Great care indeed was taken that no very flagrant acts of oppression should be committed; so that, in what sometimes happened, appearances were at least kept up; and the oppressions of government were chiefly owing to the animosities and rivalry of the merchants themselves. As an instance of the great extent to which commerce was pushed in Surat, we shall here quote from Mr Grose, what is said by Captain Hamilton of a merchant named *Abdulga-four*, viz. "That he drove a trade equal to the East India company: for he had known him fit out in a year above 20 sail of ships, between 300 and 800 tons, none of which had less of his own stock than L. 20,000, and some of them L. 25,000. After that foreign stock was sent away, it behoved him to have as much more of an inland stock for the following year's market." On the decease of this merchant, the government seized on a million of his money; and his grandson was not only deprived of all that he possessed, but barbarously murdered through the envy and treachery of his brother-merchants, and the rapacity of the governor.

The city of Surat was taken and ruined by the Portuguese in 1520; and it was not till after this misfortune that it became such a celebrated emporium. All the Indian merchants who had been accustomed to trade thither contributed to re-establish it; but it was not till near a century after that it became the general staple of Indian and European

Surat.

Surat. European merchandize; when the Dutch appearing in the Indian ocean, had deprived the Portuguese of all their conquests on that coast, and almost entirely ruined their trade. The English established a factory here in 1609, the Dutch in 1616, and the French in 1665. In process of time, the Indian seas being greatly infested by pirates, a naval officer was appointed by the Mogul to keep them in awe. This officer was named *Siddee (A) Muffoot*, who had been chief of an Ethiopian colony settled at Rajapore. Here he had collected some vessels of considerable force, and carried on some trade, till he was dispossessed by the Mahrattas; upon which he repaired to Bombay, and afterwards to Surat, where he was appointed admiral on that station to the Mogul, with a yearly revenue of about L. 36,000 Sterling. Though he had no power, independent of the marine, he seized on the castle, encroached on the town, and appropriated to himself a third part of its revenues, under pretence of arrears due in his appointed revenue. Another third was paid to the Mahrattas, to prevent their depredations upon trade in the open country; but they, not satisfied with this stipulation, watched an opportunity to plunder the town, which was kept in subjection by *Siddee Muffoot* till his death, which happened in 1756.

Siddee Muffoot was succeeded by his son, who soon rendered himself very disagreeable to the inhabitants. In 1758 the English factory was greatly oppressed by him, and the black merchants treated still worse; on which the latter applied to Mr Ellis the English chief at that time, desiring him to recommend it to the presidency of Bombay to take the castle by force out of the hands of the usurper. This proposal proving agreeable, Admiral Pococke, who was then with his Squadron at Bombay, readily concurred in supporting the expedition. The enterprize was conducted with the usual success attending the British arms; and Captain Maitland the conductor took possession of the castle with its revenue in name of the East India company, who were confirmed in the government by grants from the Mogul.

SURCHARGE OF THE FOREST, is when a commoner puts more beasts in the forest than he has a right to. See **FOREST**.

SURCHARGE of Common, is a disturbance of common of pasture, by putting more cattle therein than the pasture and herbage will sustain, or the party hath a right to do. This injury can only happen where the common is appendant or appurtenant, and of course limitable by law; or where, when in gross, it is expressly limited and certain; for where a man hath common in gross, *sans nombre*, or without stint, he cannot be a surcharge. In this case indeed there must be left sufficient for the lord's own beasts.

The usual remedies for surcharging the common are by the lord's distraining the surplus number, or by his bringing an action of trespass, or by a special action on the case, in which any commoner may be plaintiff. The ancient and most effectual method of proceeding is by writ of admeasurement of pasture.

Writ of Second SURCHARGE, de secunda superoneratione, is given by the statute of Westm. 2. 13 Edw. I. cap. 8. when, after the admeasurement of pasture hath ascertained the right, the same defendant surcharges the common again; and thereby the sheriff is directed to inquire by a jury whether the defendant has in fact again surcharged the common; and if he has, he shall then forfeit to the king the supernumerary cattle put in, and also shall pay damages to the plaintiff.

SURCINGLE, a girdle wherewith the clergy of the church of England usually tie their cassocks. See **GIRDLE**.

SURCOAT, a coat of arms, to be worn over body armour.

The surcoat is properly a loose thin taffety coat, with arms embroidered or painted on it. Such as is worn by heralds, anciently also used by military men over their armour to distinguish themselves by.

SURD, in arithmetic and algebra, denotes any number or quantity that is incommensurable to unity: otherwise called an *irrational number* or *quantity*. See **ALGEBRA**, Part I. Chap. IV.

SURETY, in law, generally signifies the same with **BAIL**.

SURF, is a term used by seamen to express a peculiar swell and breaking of the sea upon the shore. It sometimes forms but a single range along the shore, and at others three or four behind one another extending perhaps half a mile out to sea. The surf begins to assume its form at some distance from the place where it breaks, gradually accumulating as it moves forward till it gain, not uncommonly, in places within the limits of the trade-winds, a height of 15 or 20 feet, when it overhangs at top, and falls like a cascade with great force and a prodigious noise. Countries where surfs prevail require boats of a particular construction very different from the greater part of those which are built in Europe. In some places surfs are great at high, and in others at low water; but we believe they are uniformly most violent during the spring-tides.

It is not easy to assign the cause of surfs. That they are affected by the winds can hardly be questioned; but that they do not proceed from the *immediate* operation of the wind in the places where they happen, is evident from this circumstance, that the surf is often highest and most violent where there is least wind, and *vice versa*. On the coast of Sumatra the highest are experienced during the south-east monsoon, which is never attended with such gales as the north-west. As they are most general in the tropical latitudes, Mr Marsden, who seems to have paid much attention to the subject, attributes them to the trade-winds which prevail at a distance from shore between the parallels of 30 degrees north and south, whose uniform and invariable action causes a long and constant swell, that exists even in the calmest weather, about the line, towards which its direction tends from either side. This swell, when a squall happens or the wind freshens up, will for the time have other subsidiary waves on the extent of its surface, breaking often in a direction contrary to it, and which will again subside as a calm returns, without having produced on it any perceptible effect. Sumatra, though not continually exposed to the south-east trade-wind, is not so distant but that its influence may be presumed to extend to it; and accordingly at Poolo Pefang, near the southern extremity of the island, a constant southerly sea is observed, even after a strong north-west wind. This incessant and powerful swell rolling in from an ocean, open even to the pole, seems an agent adequate to the prodigious effects produced on the coast; whilst its very size contributes to its being overlooked. It reconciles almost all the difficulties which the phenomena seem to present, and in particular it accounts for the decrease of the surf during the north-west monsoon, the local wind then counteracting the operation of the general one; and it is corroborated by an observation, that the surfs on the Sumatran coast ever begin to

(A) When the Abyssinian slaves are promoted to any office under the Mogul government, they are called *Siddees*.

Surface, Surfeit. to break at their southern extreme, the motion of the swell not being perpendicular to the direction of the shore. This explanation of the phenomena is certainly plausible; but, as the author candidly acknowledges, objections may be urged to it. The trade-winds and the swell occasioned by them are remarkably steady and uniform; but the surfs are much the reverse. How then comes an uniform cause to produce unsteady effects?

In the opinion of our author it produces no unsteady effects. The irregularity of the surfs, he says, is perceived only within the remoter limits of the trade-winds. But the equatorial parts of the earth performing their diurnal revolution with greater velocity than the rest, a larger circle being described in the same time, the waters thereabout, from the stronger centrifugal force, may be supposed more buoyant; to feel less restraint from the sluggish principle of matter; to have less gravity; and therefore to be more obedient to external impulses of every kind, whether from the winds or any other cause.

SURFACE. See **SUPERFICIES.**

SURFEIT, in medicine, a sickness with a sensation of a load at the stomach, usually proceeding from some error in diet, either with regard to the quantity or quality of the food taken. Sometimes, however, a surfeit is only a plethora from indolence and full but improper feeding; in which case perspiration is defective; and eruptions form themselves on the skin.

A surfeit from animal food, as muscles, putrid flesh, &c. is best remedied by the use of vegetable acids, which may be taken diluted with water, a vomit being premised, and this even though a vomiting and purging both attend.

When an excess of feeding is the cause, the primæ viæ being evacuated, and the nature of the plethora attended to, that the load may be properly evacuated, the indication of cure will be, to recover the perspiratory discharge, consistent with which diuretics may be used in preference to medicines which produce any other evacuation.

SURFEIT, in farriery. See **FARRIERY**, § xix.

SURGE, in the sea-language, the same with a wave. See **WAVE**.

SURGEON, or **CHIRURGEON**, one that professes the art of **SURGERY**.

In England there are two distinct companies of surgeons now occupying the science or faculty of surgery; the one company called *barbers*, the other *surgeons*, which latter are not incorporated.—The two are united to sue, and be sued, by the names of masters or governors and commonalty of the mystery of barbers and surgeons of London. 32 H. VIII. c. 42.

No person using any barbery or shaving in London, shall occupy any surgery, letting of blood, or other matter; drawing of teeth only excepted. And no person using the mystery or craft of surgery shall occupy or exercise the feat or craft of barbery, or shaving, neither by himself, nor any other for his use. 32 H. VIII. c. 42.

By the same statute, surgeons are obliged to have signs at their doors.

The French chirurgians being refused to be admitted into the universities (notwithstanding that their art makes a branch of medicine), on pretence of its bordering a little on butchery or cruelty, associated themselves into a brotherhood, under the protection of S. Cosmus and S. Damian: on which account, according to the laws of their institution, they are obliged to dress and look to wounds *gratis* the first Monday of each month.

They distinguish between a chirurgian of the long robe and a barber-chirurgian. The first has studied physic, and is allowed to wear a gown. The skill of the other, besides what relates to the management of the beard, is supposed to be confined to the more simple and easy operations in chirurgery; as bleeding, tooth-drawing, &c.

They were formerly distinguished by badges: those of the long gown bore a case of instruments; the barber, a bason.

S U R G E R Y,

THAT part of medicine which treats of diseases to be cured or alleviated by the hand, by instruments, or by external applications.

CHAP. I. *History of Surgery.*

THAT surgery was coeval with the other branches of medicine, or perhaps antecedent to any of them, will not admit of doubt. The wars and contentions which have taken place among mankind almost ever since their creation, necessarily imply that there would be occasion for surgeons at a very early period; and probably these external injuries would for some time be the only diseases for which a cure would be attempted, or perhaps thought practicable.—In the sacred writings we find much mention of balsams, particularly the balm of Gilead, as excellent in the cure of wounds; though at the same time we are informed that there were some wounds which this balsam could not heal.

¹ *Surgery early practised.* Concerning the surgery practised among the Egyptians, Jews, and Asiatic nations, we know little or nothing. The ² *History of it among the Greeks.* Greeks were those from whom the art descended to us, though they confessedly received it from the eastern nations. The first Greek surgeons on record are *Æsculapius* and his sons *Podalirius* and *Machaon*. *Æsculapius* flourished about 50 years before the Trojan war; and his two sons distin-

guished themselves in that war both by their valour and skill in curing wounds. This indeed is the whole of the medical skill attributed to them by Homer; for in the plague which broke out in the Grecian camp, he does not mention their being at all consulted. Nay, what is still more strange, tho' he sometimes mentions his heroes having their bones broke, he never takes notice of their being reduced or cured by any other than supernatural means; as in the case of *Æneas*, whose thigh-bone was broken by a stone cast at him by *Dionides*. The methods which these two famous surgeons used in curing the wounds of their fellow-soldiers seems to have been the extracting or cutting out the darts which inflicted them, and applying emollient fomentations or styptics to them when necessary: and to these they undoubtedly attributed much more virtue than they could possibly possess; as appears from the following lines, where Homer describes *Eurypylus* as wounded and under the hands of *Patroclus*, who would certainly practise according to the directions of the surgeons.

Patroclus cut the forky steel away;
Then in his hands a bitter root he bruis'd,
The wound he wash'd, the styptic juice infus'd.
'The closing flesh that instant ceas'd to glow;
'The wound to torture, and the blood to flow.

Till

History.

History.

Till the days of Hippocrates we know very little of what was the practice of the Greek surgeons. From him, however, we learn, that the practice of blood-letting, cupping, and scarification, was known to them; also the use of warm and emollient fomentations, issues made with hot irons, pessaries, injections, fumigations, &c. Hippocrates also gives directions with regard to fractures, luxations, ulcers, fistulas. He directs the extension, reduction, bandages, and splints, proper to be used in fractures and luxations of different bones, with several machines to increase the extension when necessary. He directs the laxity and tightness of the bandages; the intervals for unloosing and binding them on again; the position and repose of the fractured member, and the proper regimen; and he mentions the time when a calus is usually formed. He treats also of fractures of the skull, and the method of applying the trepan. In his treatment of ulcers, he speaks of reducing fungous flesh by means of escharotics, some of which are alum, nitre, verdigrise, quicklime, &c.

In the time of Ptolemy Philopater of Egypt, medicine, all the branches of which had hitherto been practised by the same person, was now divided into three, viz. the dietetic, pharmaceutic, and surgical; from which time to the present, surgery has continued to be reckoned a distinct profession from medicine, though very improperly, in the opinion of the best authors.

3

Among the Romans,

Surgery appears not to have existed in Rome, notwithstanding the warlike genius of the people, for more than 500 years. Archagathus, a Greek, was the first professor of that art in the city; and so frequently employed the knife, hot irons, and other cruel methods of cure, that he was branded with the opprobrious title of *carnifex*, and expelled the city, where no physician or surgeon of eminence again made his appearance for 180 years. At this time Asclepiades undertook the profession of medicine; but seems to have dealt little in surgery. Neither have we any thing of importance on that subject till the time of Celsus, who flourished during the reigns of Augustus and Tiberius.—In his surgery, all the improvements from Hippocrates to his own days are collected; the most minute and trifling diseases are not omitted. An eminent surgeon, of the moderns, emphatically exhorts every person in that profession “to keep Celsus in his hands by day and by night.” He describes the signs of a fractured skull, the method of examining for the fracture, of laying the skull bare by an incision in the form of the letter X, and afterwards of cutting away the angles, and of applying the trepan, with the signs of danger and of recovery. He observed, that sometimes, though very rarely, a fatal concussion of the brain might happen, the blood-vessels within the skull being burst, yet the bone remaining entire. After the operation of the trepan, sponges and cloths wetted with vinegar, and several other applications, were made to the head; and, throughout, severe abstinence was enjoined. In violent fractures of the ribs, he ordered venesection; low diet; to guard against all agitation of the mind, loud speaking, motion, and every thing that might excite coughing or sneezing. Cloths wetted with wine, roses and oil, and other applications, were laid over the fracture. The cure of fractures, in the upper and lower extremities, he said were nearly alike; that fractures differ in degree of violence and danger, in being simple or compound, that is, with or without a wound of the flesh, and in being near to the joint. He directs the extension of the member by assistants; the reduction, by the surgeon’s hands, of the fractured bones into their natural situation; and to bind the fractured part with bandages of different lengths, previously dipped in wine and oil: on the third day fresh bandages

are to be applied, and the fractured member fomented with warm vapour, especially during the inflammation. Splints, if necessary, are to be applied, to retain the bones in a fixed position. The fractured arm is to be suspended in a broad sling hung round the neck: the fractured leg is to be inclosed in a kind of case, reaching above the ham, and accommodated likewise with a support to the foot, and with straps at the side, to keep the leg steady: in the fractured thigh-bone, the case is to extend from the top of the hip to the foot. He describes the method of treating compound fractures, and of removing small fragments of splinters of bones; and the manner of extracting darts. In luxations of the shoulder, he mentions several methods of giving force to the extension, and of replacing the dislocated bone. One method similar to that of Hippocrates was, to suspend the patient by the arm; the fore-part of the shoulder, at the same time, resting upon the top of a door, or any other such firm fulcrum. Another method was to lay the patient supine, some assistants retaining the body in a fixed position, and others extending the arm in the contrary direction; the surgeon, in the mean time, attempting, by his hands, forcibly to reduce the bone into its former place.

If a large inflammation was expected to ensue after a wound, it was suffered to bleed for some time, and blood was drawn from the arm. To wounds accompanied with considerable hæmorrhagy, he applied a sponge wet in vinegar, and constant pressure: If necessary, on account of the violence of the hæmorrhagy, ligatures were made round the vessels, and sometimes the bleeding orifice was seared up with the point of a hot iron. On the third day fresh dressings were applied. In considerable contusions, with a small wound of the flesh, if neither blood-vessels nor nerves prevented, the wound was to be enlarged. Abstinence and low diet, upon all such accidents, were prescribed; cloths wet with vinegar, and several other applications, were to be applied to the inflamed part. He observes, that fresh wounds may be healed without compound applications. In external gangrene, he cut into the sound flesh; and when the disease, in spite of every effort, spread, he advised amputation of the member. After cutting to the bone, the flesh was then separated from it, and drawn back, in order to save as much flesh as possible to cover the extremity of the bone. Celsus, though extremely diffuse in the description of surgical diseases, and of various remedies and external applications, treats slightly of the method of amputating; from which, comparing his treatise with the modern systems, we might infer that the operation was then seldomer practised than at present. He describes the symptoms of that dangerous inflammation the carbuncle, and directs, immediately to burn, or to corrode the gangrened part. To promote the suppuration of abscesses, he orders poultices of barley-meal, or of marshmallows, or the seeds of linseed and fenugreek. He also mentions the compositions of several repellent cataplasms. In the *erysipelas*, he applies ceruse, mixed with the juice of solanum or nightshade. Sal ammoniac was sometimes mixed with his plasters.

He is very minute in describing diseases of the eyes, ears, and teeth, and in prescribing a multitude of remedies and applications. In inflammation of the eyes, he enjoined abstinence and low diet, rest, and a dark room: if the inflammation was violent, with great pain, he ordered venesection, and a purgative; a small poultice of fine flower, saffron, and the white of an egg, to be laid to the forehead to suppress the flow of pituita; the soft inside of warm wheat bread dipped in wine, to be laid to the eye; poppy and roses were also added to his collyriums, and various ingredients too tedious to enumerate. In chronic watery desfluxions

History. xions of the eyes, he applied astringents, cupped the temples, and burnt the veins over the temple and forehead. He couched cataracts by depressing the crystalline lens to the bottom of the orbit. Teeth, loosened by any accident, he directs, after the example of Hippocrates, to be fastened with a gold thread to those adjoining on each side. Previous to drawing a tooth, he ordered the gum to be cut round its neck; and if the tooth was hollow, it was to be filled with lead before extraction, to prevent its breaking by the forceps. He describes not only the inflammation, but likewise the elongation, of the uvula: he also describes the polypus, and some other diseases affecting the nose.

He describes several species of hernia or rupture, and the manual assistance required in those complaints. After the return of the intestines into the abdomen, a firm compress was applied to that part of the groin through which they protruded, and was secured by a bandage round the loins. In some cases, after the return of intestinal ruptures, he diminished the quantity of loose skin, and formed a cicatrix, so as to contract over the part, to render it more rigid and capable of resisting. He describes various diseases of the genital parts, the hydrocele or dropsy of the scrotum, a difficulty of urine, and the manner of drawing off the water by a catheter; the signs of stone in the bladder, and the method of sounding or feeling for that stone. Lithotomy was at that time performed by introducing two fingers into the anus; the stone was then pressed forward to the perinæum, and a cut made into the bladder; and by the finger or by a scoop the stone was extracted. He describes the manner of performing this operation on both the sexes, of treating the patient, and the signs of recovery and of danger.

Celsus directed various corrosive applications and injections to fistulas; and, in the last extremity, opened them to the bottom with a knife, cutting upon a grooved instrument or conductor. In old callous ulcers, he made a new wound, by either cutting away the hard edges, or corroding them with verdigrise, quicklime, alum, nitre, and with some vegetable escharotics. He mentions the symptoms of caries in the bone; directs the bone to be laid bare, and to be pierced with several holes, or to be burnt or rasped, in order to promote an exfoliation of the corrupted part; afterwards to apply nitre and several other ingredients. One of his applications to a cancer was auripigmentum or arsenic. He directs the manner of tapping the abdomen in ascites, and of drawing blood by the lancet and cupping-glasses. His cupping-glasses seem not to have been so convenient as the modern: they were made either of brass or horn, and were unprovided with a pump. He cured varicose veins by action or by incision. He gives directions for extracting the dead fœtus from the womb, in whatever position it should present; and, after delivery, to apply to the private parts soft cloths wet in an infusion of vinegar and roses. In Celsus's works there is a great redundancy and superfluity of plasters, ointments, escharotics, collyriums, of suppurating and discutient cataplasms, and external applications of every kind, both simple and compound: Perhaps, amongst the multitude, there are a few useful remedies now laid aside and neglected.

The last writer of consequence who flourished at Rome was Galen, physician to the emperor Marcus Aurelius. His works are for the most part purely medicinal; although he wrote also on surgery, and made Commentaries on the Surgery of Hippocrates. He opened the jugular veins, and performed arteriotomy at the temples; directed leeches, scarification, and cupping-glasses, to draw blood. He also described with accuracy the different species of hernia or ruptures.

History. In the year 500 flourished Aëtius, in whose works we meet with many observations omitted by Celsus and Galen, particularly on the surgical operations, the diseases of women, the causes of difficult labours, and modes of delivery. He also takes notice of the dracunculus, or Guinea worm. Aëtius, however, is greatly excelled by Paulus Egineta, who flourished in 640; whose treatise on surgery is superior to that of all the other ancients. He directs how to extract darts; to perform the operation sometimes required in dangerous cases of rupture or hernia. He treats also of aneurism. Galen, Paulus, and all the ancients, speak only of one species of aneurism, and define it to be "a tumor arising from arterial blood extravasated from a ruptured artery." The aneurism from a dilatation of the artery is a discovery of the moderns. In violent inflammations of the throat, where immediate danger of suffocation was threatened, Paulus performed the operation of bronchotomy. In obstinate defluxions upon the eyes, he opened the jugular veins. He describes the manner of opening the arteries behind the ears in chronic pains of the head. He wrote also upon midwifery. Fabricius ab Aquapendente, a celebrated surgeon of the 16th century, has followed Celsus and Paulus as text-books.

From the time of Paulus Egineta to the year 900, no writer of any consequence, either on medicine or surgery, appeared. At this time the Arabian physicians Rhazes and Avicenna revived in the east the medical art, which, as well as others, was almost entirely extinguished in the west. Avicenna's *Canon Medicinae*, or General System of Medicine and Surgery, was for many ages celebrated through all the schools of physic. It was principally compiled from the writings of Galen and Rhazes. The latter had correctly described the spina ventosa, accompanied with an enlargement of the bone, caries, and acute pain. In difficult labours, he recommends the fillet to assist in the extraction of the fœtus; and for the same purpose, Avicenna recommends the forceps. He describes the composition of several cosmetics to polish the skin, and make the hair grow, or fall off.

Notwithstanding this, however, it was not till the time of Albucasis that surgery came into repute among the Arabians. Rhazes complains of their gross ignorance, and that the manual operations were performed by the physicians servants. Albucasis enumerates a tremendous list of operations, sufficient to fill us with horror. The hot iron and cauteries were favourite remedies of the Arabians; and, in inveterate pains, they reposed, like the Egyptians and eastern Asiatics, great confidence in burning the part. He describes accurately the manner of tapping in ascites; mentions several kinds of instruments for drawing blood; and has left a more ample and correct delineation of surgical instruments than any of the ancients. He gives various obstetrical directions for extracting the fœtus in cases of difficult labour. He mentions the bronchocele, or prominent tumor on the neck, which, he tells us, was most frequent among the female sex. We are also informed by this writer, that the delicacy of the Arabian women did not permit male surgeons to perform lithotomy on females; but when necessary, it was executed by one of their own sex.

From the 11th century to the middle of the 14th, the history of surgery affords nothing remarkable except the importation of that noxious disease the leprosy into Europe. Towards the end of the 15th century the venereal disease is said to have been imported from America by the first discoverers of that continent.

At the beginning of the 16th century, surgery was held in contempt in this island, and was practised indiscriminately by

History. by barbers, farriers, and low-gelders. Barbers and surgeons continued, for 200 years after, to be incorporated in one company both in London and Paris. In Holland and some parts of Germany, even at this day, barbers exercise the razor and lancet alternately.

It is within the last three centuries that we have any considerable improvement in surgery; nor do we know of any eminent British surgical writers until within the last 130 years. "In Germany (says Heister) all the different surgical operations, at the beginning even of the 18th century, were left to empirics; while regular practitioners were contented to cure a wound, open a vein or an abscess, return a fractured or luxated bone; but they seldom or never ventured to perform any of the difficult operations." He also speaks of their gross ignorance of the Latin language.

5 Writers on surgery in the 16th century. The first surgical work of the 16th century worthy of notice is that of J. Carpus. F. ab Aquapendente, an Italian, published a System of Surgery, containing a description of the various diseases, accidents, and operations. Boerhaave pays this author the following compliment: *Ille superavit omnes, et nemo illi hanc disputat gloriam; omnibus potius quam hocce carere possumus.* About the same period, A. Parey, a Frenchman, made several important additions to surgery, particularly in his collection of cases of wounds, fractures, and other accidents which occur during war. The ancients, who were ignorant of powder and fire-arms, are defective in this part of military surgery. Parey pretends to have first invented the method of tying with a needle and strong silk-thread waxed the extremities of large arteries, after the amputation of a member. The ligature of the blood-vessels is, however, merely a revival of the ancient practice, which had fallen into disuse: Throughout the dark ages, the hot iron, cauteries, and strong astringents, were substituted in its place. B. Maggus and L. Botallus wrote on the cure of gunshot wounds. J. A. Cruce wrote a system of surgery.

6 In the 17th century. In the 17th century, surgery was enriched with several systems, and with detached or miscellaneous observations. The principal authors are, M. A. Severinus, V. Vidius, R. Wiseman, Le Clerc, J. Scultetus, J. Mangetus, C. Magatus, Spigellius, F. Hildanus, T. Bartholin, P. de Marchett.

Since the commencement of the present century, surgery has been enriched with many valuable and important improvements, of the greatest part of which we have availed ourselves in the course of the following treatise. But as it would far exceed the limits of a work of this nature to enumerate the names and writings of such authors as have lived within the above period, and besides, as it appears very unimportant to do so, we shall at once proceed to the next part of our subject.

CHAP. II. Of Wounds.

SECT. I. Of Simple Wounds.

THE first thing to be considered in the inspection of a wound is, whether it is likely to prove mortal or not. This knowledge can only be had from anatomy, by which the surgeon will be able to determine what parts are injured; and, from the offices which these parts are calculated to perform, whether the human frame can subsist under such injuries. It is not, however, easy for the most expert anatomist always to prognosticate the event with certainty; but this rule he ought always to lay down to himself, to draw the most favourable prognosis the case will bear, or even more than the rules of his art will allow. This is particularly incumbent on him in sea-engagements, where the sentence of death is executed as soon as pronounced.

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ced, and the miserable patient is thrown alive into the sea, upon the surgeon's declaring his wound to be mortal. There are, besides, many instances on record, where wounds have healed, which the most skilful surgeons have deemed mortal. The following wounds may be reckoned mortal.

7 Simple Wounds. 1. Those which penetrate the cavities of the heart, and all those wounds of the viscera where the large blood-vessels are opened; because their situation will not admit of proper applications to restrain the flux of blood. Wounds which are necessarily mortal.

2. Those which obstruct or entirely cut off the passage of the nervous influence through the body. Such are wounds of the brain, cerebellum, medulla oblongata, and spinal marrow; though the brain is sometimes injured, and yet the patient recovers. Wounds likewise of the small blood-vessels within the brain are attended with great danger, from the effused fluids pressing upon the brain. Nor is there less danger where the nerves which tend to the heart are wounded, or entirely divided; for, after this, it is impossible for the heart to continue its motion.

3. All wounds which entirely deprive the animal of the faculty of breathing.

4. Those wounds which interrupt the course of the chyle to the heart; such are wounds of the receptacle of the chyle, thoracic duct, and larger lacteals, &c.

5. There are other wounds which prove fatal if neglected and left to nature: such are wounds of the larger external blood-vessels, which might be remedied by ligature.

8 Symptoms of wounds in different parts of the body. In examining wounds, the next consideration is, whether the parts injured are such as may be supposed to induce dangerous symptoms, either immediately or in some time during the course of the cure. In order to proceed with any degree of certainty, it is necessary to be well acquainted with those symptoms which attend injuries of the different parts of the body. If the skin only and part of the cellular substance is divided, the first consequence is an effusion of blood; the lips of the wound retract, become tumefied, red and inflamed, leaving a gap of considerable wideness according to the length and deepness of the wound. Besides, if a very considerable portion of skin and cellular substance is divided, a slight fever seizes the patient; the effusion of blood in the mean time stops, and the wound is partly filled up with a cake of coagulated blood. Below this cake, the small vessels pour forth a clear liquor, which in a short time is converted into pus (see the articles Pus and Mucus). Below this pus granulations of new flesh arise, the cake of coagulated blood loosens, a new skin covers the place where the wound was, and the whole is healed up; only there remains a mark, called a *cicatrix* or *scar*, showing where the injury had been received.

9 Of wounds of the skin and cellular substance. All wounds are accompanied with a considerable degree of pain, especially when the inflammation comes on, though the division reaches no farther than the skin and cellular substance. If the muscular fibres are divided, the pain is much greater, because the sound part of the muscle is stretched by the contraction of the divided part and the action of the antagonist muscle, which it is now less fitted to bear. The wound also gaps much more than where the cellular substance only is divided, inasmuch that, if left to itself, the skin will cover the muscular fibres, without any intervention of cellular substance; and not only a very-unsightly cicatrix remains, but the use of the muscle is in some measure lost.—If the muscle happens to be totally divided, its parts retract to a very considerable distance; and unless proper methods be taken, the use of it is certainly lost ever afterwards.

10 Of the arteries. If by a wound any considerable artery happens to be divided, the blood flows out with great velocity, and by starts; the patient soon becomes faint with loss of blood; nor

M

nor

Simple
Wounds.

nor does the hæmorrhagy stop until he faints away altogether, when the ends of the divided vessel close by their natural contractility; and if as much *vis vite* still remains as is sufficient to renew the operations of life, he recovers after some time, and the wound heals up as usual. The part of the artery which is below the wound in the mean time becomes useless, and its sides collapse, so that all the inferior part of the limb would be deprived of blood, were it not that the small branches sent off from the artery above the wounded place become enlarged, and capable of carrying on the circulation. Nature also, after a wonderful manner, often produces new vessels from the superior extremity of the divided artery, by which the circulation is carried on as formerly. However, the consequences of such a profuse hæmorrhagy may be very dangerous to the patient, by inducing extreme debility, polypous concretions in the heart and large vessels, or an universal dropsy. This happens especially where the artery is partially divided; because then the vessel cannot contract in such a manner as to close the orifice: however, if the wound is but small, the blood gets into the cellular substance, swelling up the member to an extreme degree, forming what is called a *diffused aneurism*. Thus the hæmorrhagy soon stops externally, but great mischief is apt to flow from the confinement of the extravasated blood, which is found to have the power of dissolving not only the fleshy parts, but also the bones themselves; and thus not only the use of the limb is entirely lost, but the patient is brought into great danger of his life, if proper assistance be not obtained in a short time.

12
Of the ligaments,
nerves, and
tendons.

Wounds of the ligaments, nerves, and tendons, are likewise attended with bad consequences. When a nerve is entirely divided, the pain is but trifling, though the consequences are often dangerous. If the nerve is large, all the parts to which it is distributed below the wound immediately lose the power of motion and sensation; nor is it uncommon, in such cases, for them to be seized with a gangrene. This, however, takes place only when all or the greatest part of the nerves belonging to a particular part are divided. If the spinal marrow, for instance, be divided near the head, the parts below soon lose their action irrecoverably; or if the bundle of nerves passing out of the axilla be divided or tied, sensation in the greatest part of the arm below will probably be lost. But though a nerve should be divided, and a temporary palsy be produced, it may again reunite, and perform its former functions. If a nerve be wounded only, instead of being divided, the worst symptoms frequently ensue.

13
Of the thorax, and the
viscera
which it
contains.

Wounds which penetrate the cavities of the thorax are always exceedingly dangerous, because there is scarce a possibility of all the viscera escaping unhurt. A wound is known to have penetrated the cavity of the thorax principally by the discharge of air from it at each inspiration of the patient, by an extreme difficulty of breathing, coughing up blood, &c. Such wounds, however, are not always mortal; the lungs have frequently been wounded, and yet the patient has recovered.—Wounds of the diaphragm are almost always mortal, either by inducing fatal convulsions immediately, or by the ascent of the stomach, which the pressure of the abdominal muscles forces up through the wound into the cavity of the thorax; of this Van Swieten gives several instances.—Even though the wound does not penetrate into the cavity of the thorax, the very worst symptoms may follow. For if the wound descends deeply among the muscles, and its orifice lies higher, the extravasated humours will be therein collected, stagnate, and corrupt in such a manner as to form various sinuses; and after having eroded the pleura, it may at length pass into the cavity of the thorax. The matter having once found a vent into this cavity,

will be continually augmenting from the discharge of the sinuous ulcer, and the lungs will at last suffer by the surrounding matter. If, in cases of wounds in the thorax, the ribs or sternum happen to become carious, the cure will be extremely tedious and difficult. Galen relates the case of a lad who received a blow upon his sternum in the field of exercise: it was first neglected, and afterwards badly healed; but, four months afterwards, matter appeared in the part which had received the blow. A physician made an incision into the part, and it was soon after cicatrized: but in a short time a new collection of matter made its appearance, and upon a second incision the wound refused to heal. Galen found the sternum carious; and having cut off the diseased part, the pericardium itself was observed to be corroded, so that the heart could be seen quite naked; notwithstanding which, the wound was cured in no very long time.

There is sometimes difficulty in determining whether the wound has really penetrated into the thorax or the abdomen; for the former descends much farther towards the sides than at the middle. But as the lungs are almost always wounded when the cavity of the thorax is penetrated, the symptoms arising from thence can scarcely be mistaken.—Another symptom which frequently, though not always, attends wounds of the thorax, is an emphysema. This is occasioned by the air escaping from the wounded lungs, and insinuating itself into the cellular substance; which being pervious to it over the whole body, the tumour passes from one part to another, till at last every part is inflated to a surprising degree. An instance is given in the Memoirs of the Royal Academy, of a tumour of this kind, which on the thorax was eleven inches thick, on the abdomen nine, on the neck six, and on the rest of the body four; the eyes were in a great measure thrust out of their orbits by the inflation of the cellular substance; and the patient died the fifth day. This was occasioned by a stab with a sword.

Wounds of the abdomen are not less dangerous than those of the thorax, on account of the importance of the viscera which are lodged there. When the wound does not penetrate the cavity, there is some danger of an hernia being formed by the protrusion of the peritonæum through the weakened integuments, and the danger is greater the larger the wound is. Those wounds which run obliquely betwixt the interstices of the muscles often produce sinuous ulcers of a bad kind. For as there is always a large quantity of fat interposed everywhere betwixt the muscles of the abdomen, if a wound happens to run between them, the extravasated humours, or matter there collected, not meeting with free egress through the mouth of the wound, often makes its way in a surprising manner through the cellular substance, and forms deep sinuosities between the muscles; in which case the cure is always difficult, and sometimes impossible.

If a large wound penetrates the cavity of the abdomen, some of the viscera will certainly be protruded through it; or if the wound is but small, and closed up with fat so that none of the intestines can be protruded, we may know that the cavity of the abdomen is pierced, and probably some of the viscera wounded, by the acute pain and fever, paleness, anxiety, faintings, hiccough, cold sweats, and weakened pulse, all of which accompany injuries of the internal parts. The mischiefs which attend wounds of this kind proceed not only from the injury done to the viscera themselves, but from the extravasation of blood and the discharge of the contents of the intestines into the cavity of the abdomen; which, being of a very putrescent nature, soon bring on the most violent disorders. Hence wounds of the abdominal viscera are very often mortal. This, however, is not always the case, for the small intestines have been totally divided, and

Simple
Wounds.14
Of the abdomen and
its viscera.

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Wounds.Simple
Wounds.

and yet the patient has recovered. Wounds both of the small and large intestines have healed spontaneously, even when they were of such magnitude that the contents of the intestine was freely discharged through the wound in it, and after part of the intestine itself has been protruded through the wound of the integuments.

When the mesentery is injured, the danger is extreme, on account of the numerous vessels and nerves situated there. Wounds of the liver, spleen, and pancreas, are also exceedingly dangerous, although there are some instances of the spleen being cut out of living animals without any considerable injury.

From the preceding account of the symptoms attending wounds in the different parts of the body, the surgeon may be enabled to judge in some measure of the event; though it must always be remembered, that wounds, even those which seemed to be of the slightest nature, have, contrary to all expectation, proved mortal, chiefly by inducing convulsions, or a locked jaw; so that no certain prognostic can be drawn on sight of recent wounds. We shall now, however, proceed to consider their treatment.

15
Treatment
of wounds.

For the cure of wounds, it has been already observed, that the ancients imagined balsams, the juice of herbs, &c. to be a kind of specifics. In after-ages, and in countries where balsams are not easily to be procured, salves have been substituted in their place; and even at this day there are many who reckon a salve or ointment essentially necessary for healing the slightest cut. It is certain, however, that the cure of wounds cannot be effected, nay, not even forwarded in the least, by ointments, unless in particular cases or by accident. That power which the human frame has of repairing the injuries done to itself, which by physicians is called *vis medicatrix naturæ*, is the sole agent in curing external injuries; and without this the most celebrated balsams would prove ineffectual. When a wound has been made with a sharp instrument, and is not extensive, if it be immediately cleaned, and all the extravasated blood sucked (A) out, it will almost always heal by the first intention in a very short time. Indeed the cures performed by this simple process are so surprising, that they would be incredible were we not assured of their reality by eye-witnesses. When this process is either neglected or proves unsuccessful, there are three stages to be observed in the cure of a wound: the first, called *digestion*, takes place when the ends of the wounded vessels contract themselves, and pour out the liquor which is converted into pus. As soon as this appears, the second stage, in which the flesh begins to *grow up*, takes place; and as this proceeds, the edges of the wound acquire a fine bluish or pearl colour, which is that of the new skin beginning to cover the wound as far as the flesh has filled it up. This process continues, and the skin advances from all sides towards the centre, which is called the *cicatrising* of the wound. For the promoting of each of these processes, several ointments were formerly much in vogue. But it is now found, that no ointment whatever is capable of promoting them; and that it is only necessary to keep the wound clean, and to prevent the air from having access to it. This, indeed, nature takes care to do, by covering the wound with a cake of coagulated blood; but if a wound of any considerable magnitude should be left entirely to nature, the pus would form below the crust of coagulated blood in such quantity, that it would most probably corrupt, and the wound degenerate into a corroding ulcer. It is necessary, therefore, to

cleanse the wound frequently; and for this purpose it will be proper to apply a little ointment spread on soft scraped lint. For the first dressing, dry lint is usually applied, and ought to be allowed to remain for two or three days, till the pus is perfectly formed; after which the ointment may be applied as just now directed; and, in a healthy body, the wound will heal without further trouble. As to the ointment employed, it is almost indifferent what it be, provided it has no acrid or stimulating ingredient in its composition.

But though, in general, wounds thus easily admit of a cure, there are several circumstances which require a different treatment, even in simple divisions of the fleshy parts, when neither the membranous nor tendinous parts are injured. These are, 1. Where the wound is large, and gapes very much, so that, if allowed to heal in the natural way, the patient might be greatly disfigured by the scar. It is proper to bring the lips of the wound near to each other, and to join them either by adhesive plaster or by suture, as the wound is more superficial, or lies deeper. 2. When foreign bodies are lodged in the wound, as when a cut is given by glass, &c. it is necessary by all means to extract them, before the wound is dressed; for it will never heal until they are discharged. When these bodies are situated in such a manner as not to be capable of being extracted without lacerating the adjacent parts, which would occasion violent pain and other bad symptoms, it is necessary to enlarge the wound, so that these offending bodies may be easily removed. This treatment, however, is chiefly necessary in gunshot wounds, of which we shall treat in the next section. 3. When the wound is made in such a manner that it runs for some length below the skin, and the bottom is much lower than the orifice, the matter collected from all parts of the wound will be lodged in the bottom of it, where, corrupting by the heat, it will degenerate into a fistulous ulcer. To prevent this, we must use compresses, applied so that the bottom of the wound may suffer a more considerable pressure than the upper part of it. Thus the matter formed at the bottom will be gradually forced upwards, and that formed at the upper part will be incapable of descending by its weight; the divided parts, in the mean time, easily uniting when brought close together. Indeed, the power which nature has of uniting different parts of the human body is very surprising; for, according to authors of credit, even if a piece of flesh be totally cut out, and applied in a short time afterwards to the place from whence it was cut, the two will unite. That a part cut out of a living body does not entirely lose its vital power for some time, is evident from the modern practice of transplanting teeth; and from an experiment of Mr Hunter's at London, he put the testicle of a cock into the belly of a living hen, which adhered to the liver, and became connected to it by means of blood-vessels*. We have there-
fore the greatest reason to hope, that the divided parts of
the human body, when closely applied to each other, will
cohere without leaving any sinus or cavity between them.
However, if this method should fail, and matter still be collected in the depending part of the wound, it will be necessary to make an opening in that part in order to let it out; after which the wound may be cured in the common way. 4. During the course of the cure, it sometimes happens that the wound, instead of filling up with fleshy granulations of a florid colour, shoots up into a glassy-like substance which rises above the level of the surrounding skin, while,

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(A) See an account of the method of sucking wounds in Mr John Bell's *Discourses on Wounds*, Part I. Discourse v. p. 215.

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Wounds.

at the same time, instead of laudable pus, a thin ill-coloured and fetid ichor is discharged. In this case the lips of the wound lose their beautiful pearl colour, and become callous and white, nor does the cicatrizing of the wound at all advance. When this happens in a healthy patient, it generally proceeds from some improper management, especially the making use of too many emollient and relaxing medicines, an immoderate use of balsams and ointments. Frequently nothing more is requisite for taking down this fungus than dressing with dry lint; at other times desiccative powders, such as calamine, tutty, calcined alum, &c. will be necessary; and sometimes red precipitate mercury must be used. This last, however, is apt to give great pain, if sprinkled in its dry state upon the wound; it is therefore most proper to grind it with some yellow bablicon ointment, which makes a much more gentle, though at the same time an efficacious escharotic. Touching the overgrown parts with blue vitriol is also found very effectual.

16
Of the re-
gimen of
patients in
wounds.

Hitherto we have considered the wounded patient as otherwise in a state of perfect health; but it must be observed, that a large wound is capable of disordering the system to a great degree, and inducing dangerous diseases which did not before exist.—If the patient is strong and vigorous, and the pain and inflammation of the wound great, a considerable degree of fever may arise, which it will be necessary to check by bleeding, low diet, and other parts of the antiphlogistic regimen, at the same that the inflamed lips of the wound and parts adjacent are to be treated with emollient fomentations or cataplasms till the pain and swelling abate. On the other hand, it may happen, when the patient is of a weak and lax habit, that the vis vitæ may not be sufficient to excite such an inflammation in the wound as is absolutely necessary for its cure. In this case, the edges of the wound look pale and soft; the wound itself ichorous and bloody, without any signs of fleshy granulations; or if any new flesh shoots up, it is of the fungous glassy kind above-mentioned. To such wounds all external applications are vain; it is necessary to strengthen the patient by proper internal remedies, among which the bark has a principal place, until the wound begins to alter its appearance. In such persons, too, there is some danger of a hectic fever by the absorption of matter into the body when the wound is large; and this will take place during the course of the cure, even when the appearances have been at first as favourable as could be wished. This happens generally when the wound is large, and a great quantity of matter formed: for by this discharge the patient is weakened; so that the pus is no sooner formed, than it is by the absorbent vessels re-conveyed into the body, and feverish heats immediately affect the patient. For this the best remedy is to exhibit the bark copiously, at the same time supporting the patient by proper cordials and nourishing diet. Indeed, in general, it will be found, that, in the case of wounds of any considerable magnitude, a more full and nourishing regimen is required than the patient, even in health, has been accustomed to; for the discharge of pus alone, where the quantity is considerable, proves very debilitating, if the patient is not strengthened by proper diet. And it is constantly found, that the cure of such sores goes on much more easily when the patient is kept in his usual habit of body, than when his system is much emaciated by a very low allowance; and, for the same reason, purgatives, and whatever else tends to weaken the constitution, are improper in the cure of wounds.

17
Of hemor-
rhagies
from
wounds.

Hæmorrhagies very frequently happen in wounds, either from a division of one large artery, or of a number of small ones. In this case, the first step to be taken by the surgeon is to effect a temporary stoppage of the blood by means of

compression. He is then to tie up all the vessels in the manner to be afterwards described.

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Wounds.

When the principal arteries of a wound have been tied, and a little blood continues to be discharged, but appears to come from sundry small vessels only, an experienced surgeon is induced to think, that the necessary compression of the bandages will in all probability effect a total stoppage of the hæmorrhagy. In a general oozing of a small quantity of blood from the whole surface of a sore, and when no particular vessel can be distinguished, there is a necessity for trusting to this remedy; but whenever an artery can be discovered, of whatever size it may be, it ought unquestionably to be secured by a ligature. But it frequently happens, that considerable quantities of blood are discharged, not from any particular vessel, but from all the small arteries over the surface of the sore. In wounds of great extent, particularly after the extirpation of cancerous breasts, and in other operations where extensive sores are left, this species of hæmorrhagy often proves very troublesome by being exceedingly difficult to suppress.

Bleedings of this kind seem evidently to proceed from two very different and opposite causes. *First*, Either from too great a quantity of blood contained in the vessels, or from an over-degree of tone in the vessels themselves; or, perhaps, from a combination of both these causes. But, *secondly*, Such evacuations undoubtedly happen most frequently in such constitutions as are very relaxed and debilitated; either from a particular state of the blood, or from a want of tone in the containing vessels, or, in some instances, from a concurrence of both.

In constitutions perfectly healthy, on the occurrence of wounds even of the most extensive nature, as soon as the larger arteries are secured, all the small vessels which have been divided are diminished, not only in their diameters, but also in their length; in consequence of which, they recede considerably within the surface of the surrounding parts. This cause of itself would probably, in the greatest number of instances, prove sufficient for restraining all loss of blood from the smaller arteries. Another very powerful agent however is provided by nature for producing the same effect. From the extremities of the divided vessels which at first discharged red blood only, there now, in their contracted state, oozes out a more thin, though viscid fluid, containing a great proportion of the coagulable parts of the blood; and this being equally distributed over the surface of the wound, by its balsamic agglutinating powers has a very considerable influence in restraining all such hæmorrhagies.

When a tedious oozing occurs in a patient young and vigorous, and where the tone of the muscular fibres is evidently great, the most effectual means of putting a stop to the discharge is to relax the vascular system, either by opening a vein in some other part, or, what gives still more immediate relief, by untying the ligature on one of the principal arteries of the part, so as to allow it to bleed freely: those violent spasmodic twitchings too, so frequent after operations on any of the extremities, when they do not depend on a nerve being included in the ligature with the artery, are in this manner more effectually relieved than by any other means.

By the same means the patient, from being in a febrile heat and much confused, soon becomes very tranquil: the violent pulsation of the heart and larger arteries abates, and the blood not being propelled with such impetuosity into the smaller vessels of the part, they are thereby left at more liberty to retract. In the mean time the patient ought to be kept exceedingly cool; wine and other cordials should be rigidly avoided; cold water, acidulated either with the mine-
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Simple
Wounds.Simple
Wounds.

ral or vegetable acids, ought to be the only drink; motion of every kind, particularly of the part affected, should be guarded against; and the wound being gently covered with soft charpie, ought to be tied up with a bandage so applied as to produce a moderate degree of pressure on the extremities of the divided parts.

As soon as a sufficient quantity of blood has been discharged, the wound being dressed, and the patient laid to rest, a dose of opium proportioned to the violence of the symptoms ought to be immediately exhibited. It ought to be remarked, however, that in all such circumstances, much larger doses of the remedy are necessary than in ordinary cases requiring the use of opiates. Small doses, instead of answering any good purpose, seem frequently rather to aggravate the various symptoms; so that whenever they are here had recourse to, they ought always to be given in quantities sufficient for the intended effect.

But hæmorrhagies of this nature happen much more frequently in relaxed enfeebled habits, where the solids have lost part of their natural firmness, and the fluids have acquired a morbid tenuity. In this case a moderate use of generous wine ought to be immediately prescribed; for nothing tends so much, in such circumstances, to restrain hæmorrhagies, as a well-directed use of proper cordials. By tending to invigorate and brace the solids, they enable the arterial system to give a due resistance to the contained fluids; and have also a considerable influence in restoring to the fluids that viscosity of texture, of which in all such instances we suppose them to be deprived.

A nourishing diet also becomes proper; the patient ought to be kept cool; and the mineral acids, from their known utility in every species of hæmorrhagy, ought also to be prescribed. Rest of body is here also proper; and opiates, when indicated either by pain or spasmodic affections of the muscles, ought never to be omitted.

Together with these remedies adapted to the general system, particular dressings, appropriated to the state of the parts to which they are to be applied, have been found very beneficial. In healthy constitutions, soon after the discharge of blood is over, the parts are covered with a viscid coagulable effusion from the mouths of the now retracted arteries; but in constitutions of an opposite nature, where the solids are much relaxed, the blood in general is found in such an attenuated state as to afford no secretion of this nature.

To supply as much as possible the deficiency of this natural balsam, different artificial applications have been invented. Dusting the part with starch or wheat-flour has sometimes been found of use, and gum arabic in fine powder has been known to answer when these failed.

Applications of this kind, indeed, have been used with success in all such hæmorrhagies, with whatever habit of body they happen to be connected; but they have always proved more particularly serviceable in relaxed constitutions, attended with an attenuated state of the blood and an enfeebled muscular system. Alcohol, or any other ardent spirits, impregnated with as great a quantity as they can dissolve of mirrh, or any other of the heating viscid gums, may be here used with freedom, though in constitutions of an opposite nature they ought never to be employed. The balsamum traumaticum of the shops, a remedy of this nature, has long been famous for its influence in such cases: but that indiscriminate use of this and similar applications which has long prevailed with some practitioners, has undoubtedly done much harm; for as they are all possessed of very stimulating powers, they of course tend to aggravate every symptom in wounds connected with a tense state of

fibres, when much pain, and especially when spasmodic muscular affections prevail.

By a due perseverance in one or other of the plans here pointed out, it will seldom happen that hæmorrhagies of this nature are not at last put a stop to: but when the contrary does occur, when, notwithstanding the use of the remedies recommended, a discharge of blood still continues; together with the means already advised, an equal moderate pressure ought to be applied over the whole surface of the sore, to be continued as long as the necessity of the case seems to indicate.

In finishing the dressings of such wounds, after the charpie and compresses have been applied, a bandage properly adapted to the part ought to conclude the whole, and in such a manner as to produce as equal a degree of pressure over the surface of the sore as possible. But it now and then happens that no bandage whatever can be so applied as to produce the desired effect; and in such cases the hand of an assistant is the only resource; which being firmly applied over the dressings, so as to produce a very equal degree of pressure, will commonly succeed when no other remedy is found to have much influence.

Wounds of the nerves, tendons, and ligaments, are attended with much more violent symptoms than those where even considerable arteries are divided, and frequently resist every method of cure proposed by the most skilful practitioners. In the simple process of blood-letting, it frequently happens that the tendinous expansion called the *aponeurosis* of the biceps muscle is wounded, or even the tendon of that muscle itself is punctured, by the point of the lancet; or sometimes a nerve which happens to lie in the neighbourhood is partially divided. Any one of these wounds, though they are the smallest we can well suppose to be given, are frequently very dangerous and difficult of cure. It sometimes immediately happens on the introduction of the lancet, that the patient complains of a most exquisite degree of pain; and when this occurs, we may rest assured that either a nerve or tendon has been wounded. On some occasions, by proper management, such as evacuating a considerable quantity of blood at the orifice newly made, by keeping the part at perfect rest, and preserving the patient in as cool a state as possible, the pain at first complained of will gradually abate, and at last go off entirely, without any bad consequence whatever. At other times, however, this pain which occurs instantaneously on the introduction of the lancet, instead of abating, begins soon to increase; a fullness, or small degree of swelling, takes place in the parts contiguous to the wound; the lips of the sore become somewhat hard and inflamed; and, in the course of 24 hours or so from the operation, a thin watery serum begins to be discharged at the orifice.

If, by the means employed, relief is not soon obtained, these symptoms generally continue in nearly the same state for two or perhaps three days longer. At this time the violent pain which at first took place becomes still more distressing; but instead of being sharp and acute as before, it is now attended with the sensation of a burning heat, which still goes on to increase, and proves, during the whole course of the ailment, a source of constant distress to the patient. The fullness and hardness in the lips of the wound begin to increase, and the swelling in the neighbouring parts gradually extends over the whole members. The parts at last become exceedingly tense and hard; an erysipelatous inflammatory colour frequently appears over the whole member; the pulse by this time has generally become very hard and quick; the pain is now intense, the patient exceedingly restless; twitchings of the tendons occur

18

Symptoms
which
sometimes
succeed
blood-let-
ting.

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19
Opinions about the causes of these symptoms.20
Mr John Hunter's opinion

cur to a greater or lesser degree; on some occasions, a locked jaw and other convulsive affections supervene; and all these symptoms continuing to increase, it most frequently happens that the torture under which the patient has been groaning is at last terminated by death.

Different opinions have prevailed respecting the cause of these symptoms. By some they have been imputed to wounds of the tendons. By others the tendons are supposed to be so entirely destitute of sensibility, as to be quite incapable of producing so much distress; so that wounds of the nerves they consider, on all such occasions, as the true cause of the various symptoms we have mentioned.

One or other of these ideas continued to be the only source for explaining the various phenomena found to occur in this malady, till a different opinion was suggested by the late ingenious Mr John Hunter of London. Mr Hunter supposes, that all the dreadful symptoms found now and then to be induced by the operation of blood-letting, may be more readily accounted for from an inflamed state of the internal surface of the vein, than from any other cause. Such a state of the vein he has often traced in horses that have died of such symptoms from venesection, and the same appearances have sometimes occurred also in the human body. And on other occasions, inflammation having in this manner been once excited, has been known to terminate in suppuration; and the matter thus produced being in the course of circulation carried to the heart, Mr Hunter supposes that in such cases death may have been induced by that cause alone.

There can be no reason to doubt the fact held forth by Mr Hunter, that in such instances the vein in which the orifice has been made has frequently after death been found greatly inflamed: but however ingenious his arguments may be for concluding that the state of the vein is the original cause of all the bad symptoms enumerated, and although we must allow that such an inflammatory affection of a vein must have a considerable influence in aggravating the various symptoms previously induced by other causes; yet we may very fairly conclude, that it could not probably in any one instance be able to account with satisfaction for their first production.

In many instances the patient, at the very instant of the operation, feels a very unusual degree of pain. In some cases, the violence of the pain is almost unsupportable. Now this we can never suppose to have been produced by the mere puncture of a vein; for although the coats of veins are not perhaps entirely destitute of feeling, yet we know well that they are not endowed with such a degree of sensibility as to render it probable such intense pain could ever be induced by their being punctured in any way whatever. This inflamed state of the veins therefore, as detected by Mr Hunter after death, must be considered rather as being produced by, than as being productive of, such affections; and that such ailments should frequently produce an inflammation of the contiguous veins, is a very probable conjecture. In the course of 48 hours or so from the operation, when the febrile symptoms are just commencing, such a degree of hardness and evident inflammation is induced over all the parts contiguous to the orifice, that it would be surprising indeed if the vein, which is thus perhaps entirely surrounded with parts highly inflamed, should escape altogether. We shall therefore proceed upon the supposition of this inflamed state of the veins being a consequence rather than the cause of such ailments; and of course we now revert to one or other of the opinions long ago adopted on this subject, that all the train of bad symptoms found on some occasions to succeed venesection, proceeds either from the wound of a nerve or of a tendon.

21
Not just.22
Really owing to the partial wounding of a nerve or tendon.

That a partial wound of a nerve will now and then produce very distressing symptoms, no practitioner will deny; but it has been attempted to be shown, that tendons are almost totally destitute of sensibility; and it has therefore been supposed, that their being wounded can never account for the various symptoms known to occur in such cases. There is great reason however to think, that in different instances the same train of symptoms have been induced by different causes; that in one instance a wounded nerve, and in others pricks of the tendons, have given rise to them, as we have already supposed.

In order to prevent as much as possible the consequent inflammation and other symptoms which usually ensue, a considerable quantity of blood should be immediately discharged at the orifice just made: the limb, for several days at least, ought to be kept in a state of perfect rest, care being at the same time taken to keep the muscles of the part in as relaxed a state as possible: the patient should be kept cool; on a low diet; and, if necessary, gentle laxatives ought to be administered.

When, notwithstanding these means, the symptoms, instead of diminishing, rather become more violent; if the lips of the orifice turn hard and more inflamed, if the pain becomes more considerable, and especially if the swelling begins to spread, other remedies come then to be indicated. In this state of the complaint, topical blood-letting, by means of leeches applied as near as possible to the lips of the wound, frequently affords much relief; and when the pulse is full and quick, it even becomes necessary to evacuate large quantities of blood by opening a vein in some other part.

The external applications usually employed in this state of the complaint are warm emollient fomentations and poultices. In similar affections of other parts no remedies with which we are acquainted would probably be found more successful; but in the complaint now under consideration, all such applications, instead of being productive of any advantage, rather do harm. The heat of the part is here one of the most distressing symptoms; and warm emollient applications rather tend to augment this source of uneasiness. The lips of the wound also are rendered still more hard, swelled, and of course more painful; and the swelling of the contiguous parts is increased. The best external remedies are cooling astringents, especially the saturnine applications. The parts chiefly affected being alternately covered over with cloths wet with a solution of saccharum saturni, and pledgits spread with Goulard's cerate, are kept more cool and easy than by any other remedy hitherto used. The febrile symptoms which occur must at the same time be attended to, by keeping the patient cool, on a low diet, preserving a lax state of the bowels; and, if necessary, farther quantities of blood ought to be evacuated.

On account of the violence of the pain, which is sometimes so excessive as to destroy entirely the patient's rest, opiates ought to be freely exhibited; and when twitchings of the tendons and other convulsive symptoms supervene, medicines of this kind become still more necessary. In order, however, to have a proper influence in this state of the complaint, opiates ought to be given in very full doses; otherwise, instead of answering any good purpose, they constantly tend to aggravate the different symptoms, not only by increasing the heat and restlessness, but by having an evident influence in rendering the system more susceptible than it was before of the pain and other distressing effects produced upon it by the wound.

It often happens, however, either from neglecting the wound or from improper treatment, that all these remedies are had recourse to without any advantage whatever: the fever, pain, and

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Method of obviating these symptoms, and curing the wound.

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and swelling of the parts continuing, convulsive affections of the muscles at last occur, all tending to indicate the most imminent danger. In this situation of matters, if we have not immediate recourse to some effectual means, the patient will soon fall a victim to the disorder; and the only remedy from which much real advantage is to be expected, is a free and extensive division of the parts in which the orifice producing all the mischief was at first made. We know well, from the repeated experience of ages, that much more pain and distress of every kind is commonly produced by the partial division either of a nerve or of a tendon, than from any of these parts being at once cut entirely across. Now the intention of the operation here recommended, is to produce a complete division of the nerve or tendon we suppose to have been wounded by the point of the lancet, and which we consider as the sole cause of all the subsequent distress.

This operation being attended with a good deal of pain, and being put in practice for the removal of symptoms from which it is perhaps difficult to persuade the patient that much danger can occur, all the remedies we have mentioned should be first made trial of before it is proposed: but at the same time, care ought to be taken, that the disorder is not allowed to proceed too far before we have recourse to it; for if the patient should be previously much weakened by the feverish symptoms having continued violent for any length of time, neither this remedy nor any other with which we are acquainted would probably have much influence. So soon therefore as the course already prescribed has been fairly tried, and is found to be inadequate to the effects expected from it, we ought immediately to have recourse to a free division of the parts chiefly affected.

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Treatment
of wounded
or ruptured
tendons.

Wherever a wounded or ruptured tendon may be situated, the limb should be placed in such a manner as will most readily admit of the retracted ends of the tendon being brought nearly together; and when in this situation, the muscles of the whole limb in which the injury has happened must be tied down with a roller, so as to prevent them from all kinds of exertion during the cure, endeavouring at the same time to keep the parts easy and relaxed. Thus in a wound or rupture of the tendon of the rectus muscle of the thigh, the patient's leg should be kept as much as possible stretched out during the cure, while the thigh should be in some degree bent, to relax the muscle itself as far as possible.

In similar affections of the tendo Achillis, the knee should be kept constantly bent to relax the muscles of the leg, and the foot should be stretched out to admit of the ends of the ruptured tendon being brought nearly into contact. A roller should be applied with a firmness quite sufficient for securing the muscles and tendons in this situation; but care must be taken to prevent it from impeding the circulation. With this view, fine soft flannel should be preferred either to linen or cotton; for being more elastic, it more readily yields to any swelling with which the limb may be attacked.

The late Dr Monro was the first who gave any accurate directions for the treatment of rupture in the large tendons; and it is perhaps given with more precision, from his having himself experienced the effects of this misfortune in the tendo Achillis.

He used a foot-sock or slipper, made of double quilted ticking, and left open at the toe; from the heel of which a strap went up above the calf of the leg. A strong piece of the same materials went round the calf, and was fastened with a lace. On the back part of this was a buckle, through which the strap of the foot-sock was passed;

by which the calf could be brought down, and the foot extended at pleasure. Besides there was a piece of tin applied to the fore part of the leg, to prevent the foot from getting into any improper posture during sleep. After proposing to walk, he put on a shoe with a heel two inches deep; and it was not till the expiration of five months that he ventured to lay aside the tin plate; and he continued the use of the high-heeled shoe for two years. The whole apparatus is represented Plate CCCCXCII. fig. 124.

From this treatment a knowledge may be formed of the treatment necessary to be followed in the laceration of tendons of other parts of the body.

In wounds of the thorax, even though none of the viscera should be wounded, we may yet reasonably expect that a considerable quantity of blood will be extravasated; and this, if very large, must be evacuated if possible. However, it ought to be particularly observed, that this extravasated blood should not be discharged before we are assured that the wounded vessels have done bleeding. When the pulse appears sufficiently strong and equal, the extremities are warm, no hiccup or convulsion appears, and the patient's strength continues, we may then know that the internal hæmorrhagy has ceased, and that the means for discharging the blood may now be safely used. Matter, water, blood, &c. have sometimes vanished from the cavities of the thorax, and been afterwards discharged by sweat, urine, &c. Yet this but seldom happens; and if we were to trust to nature only in these cases, it is certain that many would perish from a destruction of the vital viscera by the extravasated and putrid blood, who by an artificial extraction of the same blood might have been saved.

Wounds of the abdomen must be closed as soon as possible, and then treated as simple wounds; only they ought to be dressed as seldom and expeditiously as may be. A spare diet, with other parts of the antiphlogistic regimen, is here absolutely necessary. It sometimes happens, that, thro' a large wound of the abdominal integuments, the intestine comes out without being injured; yet, if it remains for any time exposed to the air, the case is commonly very dangerous. The most certain method, in all such cases, is to return the protruded part as soon as possible; for although writers in general formerly recommended warm fomentations, &c. to be previously applied, the latest authors upon this subject consider the most natural and proper fomentation to be that which is produced by the heat and moisture of the patient's belly, and that therefore the intestines, if no mortification has taken place, are to be cleared from extraneous matter, and immediately returned.

When the wound of the abdomen is large, the intestines easily prolapse, but are as easily returned. But when part of an intestine has been forced through a narrow wound, the disorder is much more dangerous. For the prolapsed intestine being distended by flatus, or the ingested aliments driven thither by the peristaltic motion, it will be inflamed, tumefied, and incapable of being returned through the stricture of the wound; whence a stoppage of the circulation and gangrene will soon follow. In this case the utmost care is to be taken to reduce the intestine to its natural size. When this cannot be accomplished by other means, some practitioners of great eminence have even advised the puncturing of the intestine in different places in order to discharge the flatus. This practice has also been recommended in an incarcerated hernia, but is exceedingly disapproved of by Mr Pott and later writers; and it seems to be very dubious whether any good can possibly arise from it. To puncture any part that is already inflamed, must undoubtedly add to the inflammation; and it is very improbable that the

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Wounds of
the thorax.

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Wounds of
the abdomen.

Simple
Wounds.

the discharge of flatus procured by the punctures would at all be a recompense for the bad consequences produced by the increased inflammation. The method of Celsus is much more eligible: It is to dilate the wound so as to reduce the intestine with ease. Sometimes part of the intestine is lost either by suppuration or gangrene. In this case, all that can be done is to strike a single stitch through the wounded bowel, and to fix it to the external wound by passing the future also through the sides of the wound. The ends of the intestine may perhaps adhere; or at any rate the wound will continue to perform the office of an anus, out of which the fæces will continue to be discharged during life. The directions given by some surgeons about inserting the upper end of the gut into the lower, and stitching them together, are perfectly impracticable, as Mr John Bell has shown in his important Discourses on Wounds*; and even if they were practicable, would certainly produce new mortification, which could not but be fatal.

* Part II.
Discourses
4th and
5th.

When the omentum appears prolapsed, the same general treatment is to be observed; only that, when it is dry and mortified, the dead part may safely be extirpated.—We shall conclude the article of abdominal wounds with a case from the memoirs of the academy of sciences for the year 1705, which shows that we ought not to despair, even though the most desperate symptoms should take place, as long as any vis vitæ remains. A madman wounded himself in 18 different places of the abdomen. Eight of these penetrated the cavity, and injured the contained viscera; he had a diarrhœa, nausea, and vomiting, tension of the abdomen, with difficult respiration and violent fever, so that his life was despaired of. During the first four days he was blooded seven times; and during the greatest part of the cure his diet consisted almost entirely of flesh-broths, with the addition of some mild vegetables. By these means he was not only cured of his wounds, but restored to his right senses. Seventeen months after, he went mad again, and threw himself over a precipice, by which he was instantly killed: on opening the body, the wounds were found to have penetrated the middle lobe of the liver, the intestinum jejunum, and the colon.

Such extraordinary cures are to be imputed, according to the satisfactory explanation of Mr J. Bell, to the abdomen being perfectly full, and constantly subjected to strong pressure between the diaphragm and abdominal muscles; which keeps the parts contiguous to a wound closely applied to it, prevents the discharge of fæces or even of blood in some measure, and gives an opportunity for a very speedy adhesion between the parts.

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Wounds of
the head.

In wounds of the head, where the cellular membrane only is affected, and the aponeurosis and pericranium untouched, phlebotomy, lenient purges, and the use of the common febrifuge medicines, particularly those of the neutral kind, generally remove all the threatening symptoms. When the inflammation is gone off, it leaves on the skin a yellowish tint and a dry scurf, which continue until perspiration takes them away; and upon the removal of the disease, the wound immediately recovers a healthy aspect, and soon heals without further trouble. But in the worst kind of these wounds, that is, where a small wound passes through the tela cellulosa and aponeurosis to the pericranium, the patient will admit of more free evacuations by phlebotomy than in the former. In both, the use of warm fomentations is required; but an emollient cataplasm, which is generally forbid in the erysipelatous swellings, may in this latter case be used to great advantage. Where the symptoms are not very pressing, nor the habit very inflammable, this method will prove sufficient; but it sometimes happens that the scalp is so

tense, the pain so great, and the symptomatic fever so high, that by waiting for the slow effect of such means the patient runs a risk from the continuance of the fever; or else the injured aponeurosis and pericranium, becoming sloughy, produce an abscess, and render the case both tedious and troublesome. A division of the wounded part, by a simple incision down to the bone, about half an inch or an inch in length, will most commonly remove all the bad symptoms; and if it be done in time, will render every thing else unnecessary.

28
Wounds of
the joints.

The wounds penetrating into the cavities of the joints do not seem at first alarming; yet, by exposure to the air, the lining membrane of such cavities acquire such a degree of sensibility as to endanger life when they are large. As soon therefore as any extraneous body, pushed into the joint, is removed, the admission of the external air is to be guarded against as much as possible. If the wound be not too large, this may be done by pulling the skin over the wound of the joint; and, to prevent its retraction, rather adhesive plaster, with proper bandaging, is to be used. But when inflammation is come on, repeated and copious blood-letting, together with fomentations, become necessary; and as the pain, in these cases, is apt to be violent, opiates must be administered; but should matter be formed in the cavity of the joint, free vent must be give to it.

SECT. II. *Of contused and lacerated Wounds.*

WHEN the small vessels are broken by a blow with any hard instrument without penetrating the skin, at the same time that the solid fibres of the part are crushed, the injury is termed a *contusion*: and when at the same time the skin is broken, it is termed a *contused and lacerated wound*; because in this case the parts are not fairly divided as with a knife, but torn asunder or violently stretched.

29
Symptoms
and effects
of contu-
sions.

Every contusion therefore, whether the skin is broken or not, may properly be reckoned a wound; for where the injury is so slight that none of the contents of the small vessels are extravasated, it scarce deserves to be mentioned. The immediate consequence of a contusion, therefore, is a swelling, by reason of the extravasation just mentioned; and the skin becomes discoloured by the blood stagnating under it: but as this fluid, even though covered by the skin, cannot long remain in its natural state, it thence happens, that the contused part soon loses its florid red colour, and becomes blue or black; the thinner parts being in the mean time gradually taken up by the absorbent vessels, which at last happens to the blood itself; the blue disappears, and is succeeded by a yellowish colour, showing that the blood is now dissolved; after which the part recovers its former appearance, and the ruptured vessels appear to have united as though nothing had happened.

These are the symptoms which attend the slightest kind of contusions; but it is evident, that where the blow is so violent as to rupture or crush some of the large nerves, or blood-vessels, all the bad consequences which attend simple wounds of those parts will ensue, and they will not at all be alleviated by the circumstance of the skin being whole. Hence it is easy to see how a contusion may produce ulcers of the worst kind, gangrene, sphacelus, carious bones, &c.; and if it happens to be on a glandular part, a scirrhous or cancer is very frequently found to ensue. Even the viscera themselves, especially of the abdomen, may be injured by contusions to such a degree as to produce an inflammation, gangrene, or scirrhous, nay instant death, without rupturing the skin.

SECT. III. *Of Gun-shot Wounds.*

GUN-SHOT wounds can be considered in no other light than contused wounds. In those made by a musket or pistol ball, the most immediate considerations are, to extract the ball, or any other extraneous body which may have lodged in the wounded part; and to stop the hemorrhagy, if there is an effusion of blood from the rupture of some considerable artery.

³⁰ Extraction of the ball or other foreign bodies. It is frequently necessary to enlarge the wound in order to extract the ball; and if it has gone quite through, (provided the situation of the part wounded will admit of its being done with safety), the wound is to be laid freely open through its whole length; by which means any extraneous body will be more readily removed, and the cure facilitated.

In order to get at the ball, or any other foreign matter, probing is to be used as sparingly as possible: and this must evidently appear to any one who will only consider the nature of the symptoms attendant on penetrating wounds of the breast or belly, either from a bullet or sharp instrument; the thrusting in a probe to parts under such circumstances being unavoidably a fresh stab on every repetition of such practice. Wherever probing is necessary, the finger is to be preferred as the best and truest probe, where it can be used.

If a ball, or any other foreign body, happens to be lodged near the orifice, or can be perceived by the finger to lie under the skin, though at some distance from the mouth of the wound, we should cut upon it and take it out: but when it is sunk deep, and lies absolutely beyond the reach of the finger, it must appear evident, upon the least reflection, that thrusting, first a long probe in quest of the bullet, and then, as has been practised likewise, a longer pair of forceps, either with or without teeth, into a wound of that kind, though with a sort of certainty to extract it, must either contuse, or irritate and inflame, the parts to a great degree; and consequently do as much, or more mischief, than the ball did at first by forcing its passage such a length of way. And should they at the same time lay hold of any considerable artery or nerve along with the ball (which can scarce ever fail of being the case), what shocking consequences would attend such a proceeding! Nor would attempts of this sort be less injurious in case a bullet should happen to be lodged in the cavity of the belly or breast. Such attempts are the less necessary, because a great number of instances have occurred, where balls have been quietly lodged in several parts of the body, till after many years they have worked themselves a passage towards the surface, and were very easily extracted; and many where balls have been entirely left behind.

³¹ Dilatation of the wound. In case the wound be occasioned by a musket or pistol shot, and of course but small, it will be necessary to dilate it without delay, provided the nature of the part will admit of this with safety: for in wounds near a joint, or in very membranous or tendinous parts, the knife, as well as forceps, should be put under some restraint; nor should any more opening be made than what is absolutely requisite for the free discharge of the matter lodged within.

Where the wounded person has not suffered any great loss of blood, and this is generally the case, it will be advisable to open a vein immediately, and take from the arm a large quantity; and to repeat bleeding as circumstances may require, the second, and even the third day. Repeated bleedings in the beginning draw after them many advantages. They prevent a good deal of pain and inflammation, lessen any feverish assaults, forward the digestion, and seldom fail to obviate imposthumations, and a long train of

complicated symptoms which are wont otherwise to interrupt the cure, miserably harass the poor patient, and too often endanger his life; and even where the feverish symptoms run high, and there is almost a certainty that matter is forming, bleeding, in that state, is very frequently of great advantage.

For the first 12 days it will be proper to observe a cooling regimen, both in respect of the medicines that may be prescribed, and the diet requisite for the support of nature. It is absolutely necessary likewise that the body be constantly kept open. Unless, therefore, nature does this office of herself, a stool should be every day procured, either by emollient clysters, or some gentle laxative taken at the mouth; and whenever there is much pain in the wounded parts, immediate recourse must be had to opium.

As to external applications, whatever is of a hot spirituous nature is remarkably injurious on these occasions, and what no wounded part can in any degree bear. The wound may be dressed with pledgits of any emollient ointment; the whole being covered with a common poultice, or, in some cases, the preparations of lead may be used. An opiate should now be administered; and the part affected being placed in the easiest and most convenient posture, the patient should be laid to rest. The formation of matter, in every contused wound, is an object of the first importance; for, till this takes place, there is often reason to suspect that gangrene may happen. With a view to hasten suppuration, the warm poultices should be frequently renewed, and they should be continued till the tension and swelling, with which wounds of this kind are usually attended, be removed, and till the sore has acquired a red, healthy, granulating appearance, when it is to be treated like a common ulcer.

Gun-shot wounds are commonly covered from the beginning with deep sloughs, and various remedies are recommended for removing them. Every appearance, however, of this kind with which they are attended proceeds entirely from contusion; and, excepting the injury be extensive, the slough is not often perceptible, or it is so thin as to come away along with the matter at the first or second dressing. Although emollient poultices be extremely useful, they ought to be no longer continued than till the effects already mentioned are produced; otherwise they will not only relax the parts, but also produce too copious a discharge of matter, which is sometimes attended with great danger. A too copious flow of matter may proceed from different causes; but in whatever way it may have been produced, the practice to be adopted must be nearly the same. Every collection which appears must have a free outlet, and the limb laid in that posture which will most readily admit of its running off. In such circumstances, nourishing diet and Peruvian bark in considerable quantities are highly useful. When the discharge continues copious, in spite of every effort to check it, detached pieces of bone or some extraneous matter are probably the cause. In such a situation nothing will lessen the quantity of matter till such substances be removed. The wound ought therefore again to be examined, and loose bodies removed. Pieces of cloth have been known to be removed by setons, when that method was practicable, after every other method had failed. Opium likewise is frequently useful in checking an excessive discharge, when it happens to be kept up by irritation.

Although no considerable hemorrhagy may happen at first in gun-shot wounds; yet after the sloughs commonly produced upon such occasions have come off, some considerable arteries may be exposed, and then a dangerous hemorrhagy may ensue. The hemorrhagy is often preceded by a great heat in the injured parts, and with a throbbing pulsatory pain. At this period it may frequently be prevented

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Regimen.34
External
Applications

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vented



Poisoned
Wounds.

vented by plentiful blood-letting, particularly local. But if the hemorrhagy has fairly taken place, and from arteries of considerable size, nothing will do but the proper application of ligatures. As the discharge in these cases would often prove dangerous before the surgeon could be procured, the attendants should be furnished with a tourniquet, with directions to apply it, upon the first appearance of blood.

35
Scarifying
improper.

Till of late years the scarifying of gun-shot wounds was a practice which prevailed very universally among surgeons; and it was expected by this, that the sloughs with which wounds are sometimes covered would sooner separate, and that the cure would thereby be more readily performed. It is now, however, known, that this practice, instead of being useful, very generally does harm by increasing the inflammation. It should therefore be laid entirely aside. When a gun-shot wound cannot easily or safely be laid open from one end to the other, perhaps it may be proper to introduce a cord through the sinus. This, however, should not be attempted till the first or inflammatory state of the wound is over: but when a cord cannot be properly introduced, on account of the situation or direction of the wound, compression may prove equally useful here as in cases of punctured wounds.

36
Mortifica-
tion.

Mortification happening after gun-shot wounds, is to be treated in the same manner as if it had arisen from any other cause, only bark is not to be promiscuously used; as, in plethoric habits, it may prove hurtful, though in debilitated relaxed habits it will be extremely useful; but even in such it should never be given while much pain and tension continue.

SECT. IV. Of Poisoned Wounds.

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Treatment
of wounds
poisoned by
the bite
of animals.

Poison may be introduced into the system various ways. The effects of the poison introduced by the stings of insects may frequently be prevented by applying immediately vinegar or ardent spirits. After inflammation has come on, the most effectual remedy is the washing the parts with cold water. The bite of a viper is not always dangerous; but as we can never judge with certainty whether the wound be poisoned or not, and as the poison of this animal acts very speedily upon the system, its bad effects ought to be prevented by every possible means. The injured part ought either to be cut out immediately, or destroyed with the actual or potential cautery.

Formerly suction was much employed, and frequently with success: it should not, however, prevent the removal of the part. After the part has been removed, we should endeavour to produce a plentiful suppuration. When the poison appears to have entered the system, the application of warm oil over the whole body has been extolled; and it has been said that advantage has been derived from the internal use of it. From some late observations, however, the efficacy of this remedy is much to be doubted. Perhaps a plentiful sweat, kept up for a considerable time, is the most certain method yet discovered. Small doses of volatile alkali frequently repeated is more to be depended on for producing this effect than any other remedy.

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Wounds
from the
bite of mad
animals.

The bite of a mad animal occasions the most formidable poisoned wound known in this country. In these wounds hydrophobia indeed does not always ensue; but when it does, death is almost certainly the consequence. A variety of nostrums for preventing and curing this disease have been held forth to the public; but there is scarcely any well attested fact of any one of them proving useful. Nothing yet known can be depended upon but the immediate removal of the injured part, either with the scalpel or the actual or potential

cautery; which, together with a plentiful suppuration, has, in different instances, appeared to answer the purpose effectually; at least, patients treated in this manner have escaped, while others bit at the same time by the same animal have suffered. The sooner the operation is performed, the more effectual it is likely to prove; but it ought not to be omitted, even though some time has elapsed from the time that the wound was inflicted; for there is reason to suppose that this poison does not enter the system so quickly as several others are observed to do. Sea-bathing has been much recommended in all ages as a preventive; but there are few well attested cases of its being attended with advantage. Many practitioners depend much on mercury; and as it can be used along with any other plan of treatment, it ought not to be neglected.

When wounds are poisoned by the application of matter from certain sores, as those of the venereal or cancerous kinds, or from any of the vegetable poisons, it is better to remove the part affected immediately, than to undergo a course of medicines generally slow and often doubtful in their operations.

The metallic poisons do not fall to be considered in this place; for however deleterious they may be when taken into the stomach, they seldom appear to be otherwise hurtful, when applied to wounds, than by irritating or corroding the parts with which they come in contact.

CHAP. III. Inflammation and its Consequences.

SECT. I. Of Inflammation and Suppuration.

INFLAMMATION of any part is accompanied with increased heat, redness, and painful tension. For the remote and proximate causes of inflammation, together with the treatment of inflammatory diseases, see *Pblegmia*, article MEDICINE. Inflammation is commonly divided into two species, the *pblegmonic* and *erythematic*. The first is distinguished by considerable swelling, throbbing pain, and circumscribed bright red colour. The second by superficial swelling, burning pain, dull red colour, apt to spread, disappearing when pressed, and quickly returning; the part affected is frequently covered with small vesicles. The consequences of inflammation are suppuration and gangrene, unless the inflammation be checked and terminated by resolution. That an inflammation will terminate in suppuration may be known from the length of time it has continued, from the remission of the pain and hardness, the greater elevation of the skin in the middle part, a change of colour from red to bluish or livid, a slight fever with shivering, and from a fluctuation of matter perceived on handling the part.

During the first stage of the inflammation, however, we ought, for the most part, to endeavour to resolve it, or prevent the suppuration. Yet some cases must be excepted. For instance, those inflammatory swellings which sometimes occur in fevers, or succeed to them, ought always to be brought to suppuration; and it might be very dangerous to attempt a resolution of them. In swellings of a scrophulous nature, it is perhaps best to do nothing at all, either with a view to resolve or suppurate. Thus it might be dangerous to make use of repellent applications, at the same time that it is by no means advisable to promote their suppuration; the cure of such swellings, when opened, proving always very troublesome; while at the same time it is known, that such swellings may remain for a very long time without any risk to the patient. In the lues venerea, too, as we are possessed of a certain antidote for the disorder, it is best not to attempt the suppuration of any buboes which may appear;

Inflamma-
tion and
Suppura-
tion.

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Symptoms
of inflamma-
tion.

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Its conse-
quences,
suppuration
and gan-
grene.

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When reso-
lution
should be
attempted.

Inflamma-
tion and
Suppura-
tion.

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Method of
resolving
inflamma-
tion.

pear; as the cure of them, when opened, very often proves extremely troublesome; and as their being opened cannot contribute any thing towards their cure.

Where the inflammation is but beginning, and the symptoms are not so violent as to affect the general system, topical remedies, with a due attention to regimen, often answer in resolving them. The first thing to be attended to in the case of every inflammation, is the removal of the exciting causes, which either have brought on the inflammation originally, or which may continue it after it is begun. Such are extraneous bodies in wounds, pieces of fractured bones, luxations, &c. Of all the various applications for an inflamed part, those of a sedative nature are chiefly to be depended upon; and, next to these, emollients. Of the former kind we may consider all the different preparations of lead dissolved in vinegar; together with vinegar itself, which generally acts also as a sedative. Among the latter we may place the mild expressed oils, as also the soft ointments made with these oils and pure wax.

When we speak of sedative medicines, however, it must not be understood that all of that class are to be used indiscriminately. Thus opium, though one of the most powerful of all sedatives, yet as its application, externally, to the human body, is always attended with some degree of irritation, however useful it may at times be found in some particular species of inflammatory disorders, will never, probably, as an external application, become of general use in these cases. Warm emollient fomentations also, though powerful sedatives, as tending more effectually to remove tension and pain than perhaps any other remedy, are constantly found to be improper where a resolution is to be wished for. Their constant effect is, either to bring the swelling to a suppuration, or to relax the parts in such a manner as to render the removal of the disorder always exceedingly tedious.

Mr Bell recommends the preparations of lead as proper applications, in cases of external inflammation, where we wish for a resolution. The best method of applying it, he says, is in the form of a watery solution; and he gives the following formula: "R. Sacchar. saturn. $\mathfrak{ss}$.; solve in acet. pur. $\mathfrak{iv}$.; et adde aq. fontan. distillat. $\mathfrak{ij}$. The addition of vinegar renders the solution much more complete than it otherwise would be; and without it indeed a very considerable proportion of the lead generally separates and falls to the bottom.

In making use of this solution in cases of inflammation, as it is of consequence to have the parts affected kept constantly moist with it, cataplasms prepared with it and crumb of bread in general answer that intention exceedingly well. But when the inflamed part is so tender and painful as not easily to bear the weight of a poultice, which is frequently the case, pieces of soft linen moistened with the solution answer the purpose tolerably well. Both should be applied cold, or at least with no greater warmth than is merely necessary for preventing pain or uneasiness to the patient: they should be kept almost constantly at the part, and renewed always before turning stiff or hard.

When the tension and irritation on the skin are considerable, emollients are often attended with very great advantage: the parts affected being, in such a state of the disorder, gently rubbed over with any of the mild expressed oils two or three times a-day, the tension, irritation, and pain are often very much relieved, and the discussion of the tumor thereby greatly promoted.

In every case of inflammation, indeed, emollient applications would afford some relief. But as the preparations of lead, already recommended, prove in all such disorders still more advantageous; and as unguents of every kind tend considerably to blunt the action of lead; these two sets of

remedies should as seldom as possible be allowed to interfere with one another; and emollients should accordingly never be prescribed, but when the circumstances already mentioned, of irritation, tension, and pain, are so considerable as to render their application altogether necessary.

When the part affected with inflammation is not very tender, or lies deep, applications of vinegar are often had recourse to with considerable advantage: the most effectual form of using it seems to be by way of cataplasm, made with the strongest vinegar and crumb of bread. In such cases, an alternate use of this remedy, with the saturnine solution, has produced more beneficial effects than are commonly observed from a continued course of any one of them.

At the same time that these applications are continued, bleeding with leeches, or cupping and scarifying, as near as possible to the part affected, is generally of very great service; and in no case of local inflammation should ever be omitted. In all such cases, the whole body, but more especially the diseased part, should be preserved as free as possible from every kind of motion; and, for the same reason, the necessity of a low cooling diet, in every inflammatory disorder, appears obvious, as does also a total abstinence from spirituous and fermented liquors.

In slight cases of inflammation, a due perseverance of the several articles taken notice of will, in general, be found sufficient for every purpose. But when there is likewise a full, hard, or quick pulse, with other symptoms of fever, general blood-letting becomes necessary; the quantity of blood taken away being always to be determined by the violence of the disorder, and by the age and strength of the patient. Evacuation, however, should never be carried to a greater height than what is merely necessary for moderating the febrile symptoms; for if suppuration should take place after the system is too much reduced, its progress is thereby rendered much more slow and uncertain, nor will the patient be so able to bear the discharge that must ensue upon opening the abscess. The use of gentle laxatives, together with cooling diaphoretic medicines, are also attended with very good effects.

These different evacuations being premised, the next object of consequence is to procure ease and quietness to the patient; which is often, in inflammatory cases, of more real service than any other circumstance whatever. The most effectual remedy for this purpose is opium; which, when pain and irritation are considerable, as in extensive inflammations very frequently happens, should never be omitted. In large wounds, especially after amputations and other capital operations, also in punctures of all kinds, large doses of opium are always attended with remarkable good effects. In all such cases, however, opium, in order to have a proper influence, should, as was observed, be administered in very large doses; otherwise, instead of proving serviceable, it seems rather to have the contrary effect; a circumstance which is perhaps the chief reason for opiates in general having been very unjustly condemned in every case of inflammation.

By a proper attention to the different circumstances taken notice of, in the course of three or four days, and sometimes in a shorter space of time, resolution of the tumor will in general begin to take place; at least before the end of that period it may, for the most part, be known how the disorder is to terminate. If the heat, pain, and other attending symptoms abate, and especially if the tumor begins to decrease, without the occurrence of any gangrenous appearances, we may then be almost certain that by a continuance of the same plan a total resolution will in time be effected.

But, on the contrary, if all the different symptoms rather

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Blood-let-
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proper for
this pur-
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Inflamma-
tion and
Suppura-
tion.

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Method of
promoting
suppura-
tion.

increase; and especially if the tumor turns larger, and somewhat soft, with an increase of throbbing pain; we may then with tolerable certainty conclude, that suppuration will take place; and should therefore immediately desist from such applications as were judged proper while a cure was thought practicable by resolution, and endeavour to assist nature as much as possible in the formation of pus, or what is called *maturation* of the tumor. For this purpose there is nothing better than to preserve a proper degree of heat in the parts. This is commonly done by the means of warm fomentations and cataplasms; and when these are regularly and frequently renewed, nothing, it is probable, could more effectually answer the purpose. But in the ordinary manner in which they are applied, by the cataplasms being renewed only once, or at most twice a day, they must always, it is imagined, do more harm than good. For so soon as the degree of heat they were at first possessed of is dissipated, the moisture kept up by them, with the consequent evaporation which ensues, must always render the part a great deal colder than if it had been merely wrapped in flannel without the use of any such application.

In order to receive all the advantages of such remedies, the part affected should be well fomented with flannels pressed out of any warm emollient decoction, applied as warm as the patient can easily bear them, continued at least half an hour at once, and repeated four times a day.

Immediately after the fomentation is over, a large emollient poultice should likewise be applied warm, and renewed every second or third hour at farthest. Of all the forms recommended for emollient cataplasms, a common milk and bread poultice, with a proportion of butter or oil, is perhaps the most eligible; as it not only possesses all the advantages of the others, but can at all times be more easily obtained.

Roasted onions, garlic, and other acrid substances, are frequently made use of as additions to maturing cataplasms. When there is not a due degree of inflammation in the tumor, and when it appears probable that the suppuration would be quickened by having the inflammatory symptoms somewhat increased, the addition of such substances may then be of service; but when stimulants are necessary in such cases, a small proportion of strained galbanum, or of any of the warm gums, dissolved in the yolk of an egg, and added to the poultices, is a more certain form of applying them. Whenever the inflammation, however, takes place to a proper degree, such stimulating substances never can be necessary; and in many cases, it is apprehended, they may even do mischief.

In such tumors as, from their being possessed of little or no inflammation, are commonly said to be of a cold nature, as they are generally indolent, and proceed very slowly to suppuration, plasters composed of the warm gums are often had recourse to with considerable advantage. In such cases, they are not only of use by the stimulus and irritation they occasion, but by the heat which they tend to preserve in the part. They become particularly necessary when the patient, by being obliged to go abroad, cannot have cataplasms frequently enough renewed, or so conveniently applied; but when some such objection does not occur, the latter, for very obvious reasons, should always be preferred.

45
Dry cup-
ping.

Dry cupping, as it is termed, that is, cupping without the use of the scarificator, upon or as near as possible to the part affected, is frequently had recourse to with advantage in promoting the suppuration of tumors. It is only, however, in such as these last mentioned, where there seems to be a deficiency of inflammation, that it can ever either be necessary or useful; but in all tumors of a real indolent na-

ture, and where there is still some probability of a suppuration, no remedy is more effectual.

These different applications, under the restrictions taken notice of, being continued for a longer or shorter time, according to the size of the tumor, its situation, and other circumstances, a thorough suppuration may in general at last be expected.

Matter being fully formed in a tumor, is known by a remission of all the symptoms taking place; the throbbing pain, which before was frequent, now goes off, and the patient complains of a more dull, constant, heavy pain: the tumor points at some particular part, generally near to its middle; where, if the matter is not encysted, or deep seated, a whitish yellow appearance is observed, instead of a deep red that formerly took place; and fluctuation of a fluid underneath is, upon pressure, very evidently discovered. Sometimes, indeed, when an abscess is thickly covered with muscular and other parts, though, from concurring circumstances, there can be little doubt of there being even a very considerable collection of matter, yet the fluctuation cannot be readily distinguished: it does not, however, often happen, that matter is so very deeply lodged as not to be discovered upon proper examination.

This, however, is a circumstance of the greatest consequence in practice, and deserves more attention than is commonly given to it. In no part of the surgeon's employment is experience in former similar cases of greater use to him than in the present; and however simple it may appear, yet nothing, it is certain, more readily distinguishes a man of observation and extensive practice, than his being able easily to detect collections of deep-seated matter; whilst nothing, on the contrary, so materially affects the character of a surgeon, as his having, in such cases, given an inaccurate or unjust prognosis; as the event, in disorders of that nature, comes generally at last to be clearly demonstrated to all concerned.

Together with the several local symptoms of the presence of pus already enumerated, may be mentioned the frequent shiverings to which patients are liable on its first formation: these, however, seldom occur so as to be distinctly observed, unless the collection is considerable, or seated internally in some of the viscera.

After the matter is fully formed, and the abscess brought to maturity, the only remedy is to open it, and give vent to the pus it contains. In many cases, indeed, nature will do the work, and abscesses, when superficially seated, will certainly burst of themselves: but where the matter lies deep, we are by no means to wait for this spontaneous opening; as the pus will acquire an acrimony before it can break through the integuments, which may prove very prejudicial to health. However, it is a general rule not to open abscesses till a thorough suppuration has taken place; for, when laid open long before that period, and while any considerable hardness remains, they commonly prove more troublesome, and seldom heal so kindly.

In some cases, however, it is necessary to deviate from this general rule, and to open them a good deal sooner; particularly in all such critical abscesses as occur in malignant fevers. In like manner, in the plague, we are commonly advised to open such tumors, so soon as they are at all tolerably advanced, and not to wait till they are fully matured; as, from experience in these disorders, it is found to be of more consequence, for the removal of the original disease, to have a quick discharge of matter produced, than any harm the patient can ever suffer from having a swelling somewhat prematurely laid open.

In abscesses, also, situated on any of the joints, or upon either

Inflamma-
tion and
Suppura-
tion.

46
Signs that
matter is
formed.

47
Of opening
abscesses.

Inflamma-
tion and
Suppura-
tion.

either of the large cavities of the breast and abdomen, and more especially when they seem to run deep, they should always be opened as soon as the least fluctuation of matter is discovered. For, when the resistance is on every side equal, they just as readily point inwardly as outwardly: and the consequence of a large abscess bursting into either of the large cavities, is well known most frequently to prove fatal: An instance of which, in the following case, with very little attention, might have been prevented. A surgeon of eminence, and of very extensive practice, was applied to by a young healthy-looking man, with a large abscess upon the left side of his chest. A fluctuation of a fluid was, upon pressure, very evidently discovered; and it was agreed, by other two practitioners who were present, that an opening should be made to give vent to the matter. But the operator, being much engaged in business, could not fix on an earlier period for doing it than the third day from the patient's applying to him: unluckily, however, the patient died suddenly in his bed the night before the abscess was to have been opened. On examining the body, the tumor had disappeared entirely, without any external opening being observable; and, on opening the thorax, it was found to have burst inwardly upon the lungs, and produced immediate suffocation.

In every other circumstance, however, except in the cases alluded to, the rule in opening abscesses is, as was already remarked, To allow a thorough suppuration to take place, before any vent whatever be given to the matter; and it being then determined to lay the collection open, the next question that occurs, is with respect to the manner of doing it.

There are three ways of opening an abscess so as to give an outlet to the matter; by caustic, by incision, or by the introduction of a seton. The first is more agreeable to timid patients, who are afraid of the pain of incision, but is attended with some inconveniences which render the method of incision much preferable. Caustic acts slowly, and produces a long continued pain; besides, no kind of caustic has yet been invented, the effects of which can be confined to a certain determinate extent; hence the patient is liable to suffer much unnecessary pain, as the caustics commonly employed are either the lapis infernalis or lunar caustic. The abscess is to have a slip of adhesive plaster applied to it, with a slit cut in it of a size somewhat less than the opening is intended to be. This slit is to be filled with caustic reduced into a powder, and wetted to make it act more quickly. It is then to be covered over with a plaster, and the whole is secured with a firm compress and bandage. The time necessary for the caustic to make a sufficient opening will depend upon the thickness of the skin and strength of the caustic; but generally it requires several hours. When we find that an eschar is made, it is to be softened with any emollient ointment until it can be readily separated; after which, the matter is to be discharged, and the abscess treated as one opened by incision.

49
By the
knife,

The method of opening abscesses by the knife is, to make an incision of such a size as to give free vent to the matter. The opening is to be made in the under part of the tumor, that the matter may pass readily out. It has been a practice among surgeons either to open a large abscess from end to end, or at least through two-thirds of its length; but from the bad consequences which often attend this method, the latest practitioners have thought it better merely to give a free discharge to the matter, without exposing the part to the action of the air.

50
By a seton.

The third method, viz. that by the seton, is now frequently employed. It has the advantage of being attended with little pain, emptying the abscess in a gradual manner,

and completely preventing the access of the air, which, in the other two methods, is often attended with bad consequences; and it frequently performs a cure in a much shorter time.

There are various instruments for introducing the seton: it may even frequently be done by a lancet and common probe; but the instruments represented in Plate CCCCLXXXVII. fig. 1. and 2. are more frequently employed. One of these being threaded with glover's soft silk, is to be introduced through the upper part of the tumor; but if the blunt one (fig. 2.) be employed, it will be necessary to have the assistance of a lancet; the instrument is then to be brought out at the under part of the tumor, and in this way the matter will be allowed to run gradually off.

The usual mode of dressing an abscess the first time is with dry lint. In the course of dressing, it will be proper to have regard to the situation of the abscess, and as much as possible to make the patient favour the discharge by his ordinary posture: and to this end also, the discharge must be assisted by compress and bandage: the compress may be made of soft old linen, applied according to the nature of the part and the season of the year. The frequency of dressing will depend on the quantity of discharge: once in 24 hours is ordinarily sufficient; but sometimes twice, or perhaps three times, is necessary.

SECT. II. Of Gangrene.

THE other consequence of inflammation is gangrene, which may terminate in mortification. When the colour of an inflamed part changes to a dark red, when blisters arise on it containing an ichorous fluid, we know that it has become gangrenous. When it becomes black, flaccid, and insensible, when it loses heat, and acquires a putrid smell, it has proceeded to complete mortification. A gangrene seldom affects those who enjoy a good habit of body, though, even in them, it may be brought on accidentally by whatever destroys the texture of a part; as contusion, long continued pressure, or whatever deprives a part of its nourishment. In like manner, cold, by putting a stop to the circulation, may produce gangrene, and frequently does so in cold climates. This comes on suddenly, without any pain or previous inflammation; and the patient himself is frequently insensible of it, till he is informed of his situation by some other person.

A defect in the circulation, in extreme old age, frequently occasions mortification in the extremities.

There are some instances of what is called *dry gangrene*, in which the parts continue totally mortified for a great length of time, without either turning very flaccid, or running into dissolution. But such cases never occur from inflammation; they happen commonly from the flow of blood to such parts being put a stop to by compression of one kind or another, as tumors, ligatures, or other similar causes, obstructing the principal arteries which used to supply them; which, when the stoppage of the circulation is complete, always occasions a very slow, tedious, mortification; and as the parts in such instances are no longer supplied with fresh quantities of fluids, while a considerable evaporation must still be going on, such a degree of humidity cannot therefore possibly occur as does in other cases of gangrene. So that species of the disorder has, perhaps, with propriety enough, been termed the *dry gangrene*.

There is another variety of the disease termed *white gangrene*; in which the parts supposed mortified do not turn black, but retain nearly their former colour, &c. Whether such a complaint, however, can with propriety be denominated *gangrene* or not, may properly be doubted; but as it is chiefly that species of the disorder which succeeds inflammation,

51
White gan-
grene.

Gangrene. mation that is here particularly treated of, and in which no such varieties are ever observed, it is not necessary to carry the inquiry farther.

53 Prognosis. The prognosis in every case of gangrene is doubtful at first, as, even in the slightest cases, the patient may suffer from the spreading of the disease; but slight cases, from external injuries, are more favourable than those which arise from internal causes, though no person can be considered safe till the diseased parts are separated, and even entirely cast off. When inflammation happens round a mortified part, more especially if pus be formed, we may pretty certainly pronounce that the mortified part will be thrown off.

54 Means of preventing gangrene arising from inflammation. When there is reason to suspect from the violence of the fever and great heat of the inflamed part, that it will terminate in gangrene, blood-letting, and whatever may have a tendency to moderate the inflammation, may check its progress. But as the patient, in such cases, is sometimes apt to sink afterwards, nothing more ought to be done than is merely necessary to moderate the present symptoms. If an inflamed surface put on a gangrenous appearance when the patient is weak, and the pulse low, we must have recourse to whatever may invigorate the system, viz. a nourishing diet, with the free use of wine. Peruvian bark likewise is to be given in as great quantities as the stomach of the patient will permit. When the stomach cannot bear enough in substance, which is the best form of exhibiting it, it may be given either in form of tincture or joined with aromatics. External applications, such as are of a stimulating nature, may likewise be useful.

55 Arising from cold. In the case of gangrene arising from cold, the part must be immersed in very cold water, or rubbed with snow; for if any thing warm be applied, or the patient brought near a fire, it certainly mortifies. If the whole body has become torpid with cold, the same practice must be followed; the very cold water should be afterwards changed for some that is a little warmer, and the patient gradually brought to a proper degree of heat. Rubbing with salt is sometimes found useful. If the whole body be benumbed, cordials are not to be administered too suddenly. A glass of cold wine should first be given, afterwards warm wine by itself, or with spices. If stronger cordials be required, ardent spirits may be employed. Notwithstanding the greatest attention, however, a mortification sometimes takes place, and in some instances very suddenly; as in the case of carbuncle, where, after an inflammation has continued for scarcely 24 hours, the parts become black, and end in real mortification.

56 Scarifications and external application to mortified parts improper. In the treatment of mortified parts, a variety of external applications have been pointed out, and particularly those of the antiseptic kind; such as all the warm gums and balsams, ardent spirits, and even alcohol: and to admit of their nearer application to the sound parts, with a view to the preservation of these from putrefaction, deep scarifications through the diseased, and into the sound parts, have been generally recommended. But although such articles may be of use in preserving dead animal substances from corruption; yet that they will always prove serviceable in the same manner in living bodies, is probably very much to be doubted. And it is even apprehended, by the strong irritation they always occasion when applied to a living fibre, that, in such cases as the present, they may rather do mischief; it being only a very slight degree of inflammation that is required to bring on a suppuration. The incisions, when carried into the sound parts, with a view to facilitate the operation of such remedies, may likewise do harm; not only from the risk of wounding the blood-vessels, nerves, and tendons, that lie in the way, but also by allowing a free and farther entrance of the putrescent fluids into the parts not yet affected: and unless they are carried so deep as freely to

reach the sound parts, applications of the antiseptic kind can never have any effect in answering the purpose for which they were intended.

All the advantages commonly observed from the great variety of applications recommended for gangrene, are obtained with more ease, and generally with more certainty, from the use of any gentle stimulating embrocation; which, by exciting a slight irritation upon the surface, and especially when assisted by a free use of the bark, at last commonly produces such a degree of inflammation as is wished for. With this view, a weak solution of sal ammoniac in vinegar and water has been known to answer exceedingly well: a dram of the salt to two ounces of vinegar and six of water, forms a mixture of a very proper strength for every purpose of this kind; but the degree of stimulus can be easily either increased or diminished, according to circumstances, by using a larger or smaller proportion of the salt.

Although, for the reasons formerly advanced, incisions may not in general be proper; yet in such cases where the mortification runs very deep, it is sometimes of service to make scarifications into the diseased parts, so as to remove part of them; which, by taking off a considerable load perhaps of putrid flesh, not only lessens the fetor, which in such cases is always considerable, but often renders it more easy for the sound parts to free themselves from the remainder. When with this view, however, incisions are had recourse to, care should always be taken that they be not carried the length of the sound parts.

When by the use of external or internal remedies, a separation of the mortified part has been effected, and a discharge of pus produced, the remaining sore is then to be considered merely as a simple purulent ulcer, and may be treated in the same manner.

CHAP. IV. Of Ulcers, White Swellings, Cancers, and Burns.

SECT. I. Of Ulcers.

A solution of continuity in any of the softer parts of the body, discharging either pus, sanies, or any other vitiated matter, is termed *ulcer*; and when the same circumstances happen to the bones, the term *caries* or *carious ulcer* is adopted.

Ulcers are distinguished by their particular disorders, though it seldom happens that the affections are not complicated; and when we lay down rules for the management of one species of ulcer, it is generally requisite to apply them to almost all others. However, the characters of most eminence are, the callous ulcer, the sinuous ulcer, and the ulcer with caries of the adjacent bone: besides this there is the putrid, the corrosive, the varicose ulcers, &c.; but as they have acquired their names from some particular affection, we shall speak of the treatment of them under the general head of ulcers.

It will be often in vain to pursue the best means of cure by topical application, unless we are assisted by internal remedies; for as many ulcers are the effects of a particular disposition of body, it will be difficult to bring them into order while the cause of them remains. Those which are cancerous and scrophulous seem to gain the least advantage from physic; for if in their beginnings they have sometimes been very much relieved, or cured, by salivation, or any other evacuation, they are also often irritated and made worse by them.

When an ulcer becomes foul, and discharges a nasty thin ichor, the edges of it, in process of time, tuck in, and growing skinned and hard, give it the name of a *callous ulcer*;

Ulcers.

57 Different kinds of ulcers.

58

Of callous ulcers.

^{Ulcers.}cer; which, as long as the edges continue in that state, must necessarily be prevented from healing. But we are not immediately to destroy the lips of it, in expectation of a sudden cure; for while the malignity of the ulcer remains which was the occasion of the callosity, the new lips will be subject to a relapse of the same kind, however often the external surface of them be destroyed: we are to endeavour to bring the body of the ulcer into a disposition to recover by other methods. It sometimes happens to poor laborious people, who have not been able to afford themselves rest, that lying a-bed will in a short time give a diversion to the humours of the part, and the callous edges, softening, will without any great assistance shoot out a cicatrix, when the ulcer is grown clean and filled with good flesh. The effect of a salivation is generally the same; and even an issue sometimes disposes a neighbouring ulcer to heal. But though callosities be frequently softened by these means, yet when the surface of the ulcer begins to yield thick matter and little granulations of red flesh shoot up, it will be proper to quicken nature by destroying the edges of it, if they remain hard. The manner of doing this, is by touching them a few days with the lunar caustic, or *lapis infernalis*. Some choose to cut them off with a knife: but this is very painful, and not more efficacious. When the lips do not tuck down close to the ulcer, but hang loose over it, as in some venereal buboes, the easiest method is to cut them off with the scissars.

To digest the ulcer, or to procure good matter from it when in a putrid state, there are an infinity of ointments invented; but the basilico flavum, alone, or softened down sometimes with turpentine, and sometimes mixed up with different proportions of red precipitate, seems to serve the purpose of bringing an ulcer to cicatrization as well as any of the others. When the ulcer is incarnated, the cure may be finished as in other wounds; or if it do not cicatrize kindly, it may be washed with aq. calcis, or aq. phag. or dressed with a pledget dipt in tinct. myrrhæ: and if excoriations are spread round the ulcer, they may be anointed with sperm. cet. ointment, or any other soft ointment.

The red precipitate has of late years acquired the credit it deserves for the cure of ulcers; but, by falling into general use, is very often unskillfully applied: when mixed with the basilicon, or, what is nearer, a cerate of wax and oil, it is most certainly a digestive, since it hardly ever fails to make the ulcer yield a thick matter in 24 hours, which discharged a thin one before the application of it.

⁵⁹Of destroy-
ing fungous
flesh. If the ulcer produces a spongy flesh, sprouting very high above the surface, it will be necessary to destroy it by some of the escharotics, or the knife. This fungus differs very much from that belonging to healing wounds, being more eminent and lax, and generally in one mass; whereas the other is in little distinct protuberances. It approaches often towards a cancerous complexion, and when it rises upon some glands sometimes actually degenerates into a cancer. When these excrescences have arisen in venereal ulcers, escharotics should be applied. Those in use, are the vitriol, the lunar caustic, the lapis infernalis, and more generally the red precipitate powder.

It is but seldom that these inveterate funguses appear on an ulcer; but it is very usual for those of a milder kind to rise, which may often be made to subside by pressure and the use of mild escharotics: however, if the aspect of the sore be white and smooth, as happens in ulcers accompanied with a dropsy, and often in young women with obstructions, it will answer no purpose to waste the excrescences until the constitution is repaired, when most probably they will sink without any assistance. In ulcers also, where the subjacent bone is carious, great quantities of loose flabby flesh will

grow up above the level of the skin: but as the caries is the cause of the disorder, it will be in vain to expect a cure of the excrescence until the rotten part of the bone be removed; and every attempt with escharotics will be only a repetition of pain to the patient, without any advantage.

When the pain and inflammation are excessive, bleeding and other evacuations will often be serviceable; and above all things, rest and a horizontal position; which last circumstance is of so great importance to the cure of ulcers of the legs, that unless the patient will conform to it strictly, the skill of the surgeon will often avail nothing: for as the indispotion of these sores is in some measure owing to the gravitation of the humours downwards, it will be much more beneficial to lie along than sit upright, though the leg be laid on a chair; since even in this posture they will descend with more force than if the body was reclined.

⁶⁰Ulcers accompanied with varices. In ulcers of the legs, accompanied with varices or dilatations of the veins, the method of treatment will depend upon the other circumstances of the sore; for the varix can only be assisted by the application of bandage, which must be continued a considerable time after the cure. The neatest bandage is the laced stocking, which is particularly serviceable in this case; though also, if the legs be œdematous, or if, after the healing of the ulcers, they swell when the patient quits his bed, it may be worn with safety and advantage. There are instances of one vein only being varicous; which, when it happens, may be destroyed by tying it above and below the dilatation, as in an aneurism; but this operation should only be practised where the varix is large and painful.

⁶¹Cure of old ulcers dangerous. Ulcers of many years standing are very difficult of cure; and in old people the cure is often dangerous, frequently exciting an asthma, a diarrhoea, or a fever, which destroys the patient, unless the sore break out again: so that it is not altogether advisable to attempt the absolute cure in such cases; but only the reduction of them into better order, and less compass, which, if they be not malignant, is generally done with rest and proper care. The cure of those in young people may be undertaken with more safety; and in all cases of stubborn ulcers, the bark, very copiously given, will be found of the utmost service.

⁶²Of sinuous ulcers. When an ulcer or abscess has any sinuses or channels opening and discharging themselves into the sore, they are called *sinuous ulcers*. These sinuses, if they continue to drain a great while, grow hard in the surface of their cavity, and then are termed *fistule*, and the ulcer a *fistulous ulcer*; also, if matter be discharged from any cavity, as those of the joints, abdomen, &c. the opening is called a *sinuous ulcer* or a *fistula*.

⁶³Treatment. The treatment of these ulcers depends upon a variety of circumstances. If the matter of the sinus be thick, strict bandage and compress will sometimes bring the opposite sides of the sinus to a reunion: if the sinus grow turgid in any part, and the skin thinner, showing a disposition to break, the matter must be made to push more against that part, by plugging it up with a tent; and then a counter opening must be made, which proves often sufficient for the whole abscess, if it be not afterwards too much tented, which locks up the matter and prevents the healing; or too little, which will have the same effect: for dressing quire superficially does sometimes prove as mischievous as tents, and for nearly the same reason; since suffering the external wound to contract into a narrow orifice before the internal one be incarnated, does almost as effectually lock up the matter as a tent. To preserve, then, a medium in these cases, a hollow tent of lead or silver may be kept in the orifice, which, at the same time that it keeps it open, gives vent to the matter. The abscesses where the counter opening is made

Ulcers.

made most frequently are those of compound fractures, and the breast: but the latter do oftener well without dilatation than the former; though it must be performed in both, if practicable, the whole length of the abscess, when after some trial the matter does not lessen in quantity, and the sides of it grow thinner; and if the sinuses be fistulous, no cure need be expected without dilatation.

When an ulcer with loose rotten flesh discharges more than the size of it should yield, and the discharge is oily and stinking, in all probability the bone is carious; which may easily be distinguished by running the probe through the flesh: and if so, it is called a *carious ulcer*. The cure of these ulcers depends principally upon the removal of the rotten part of the bone, without which it cannot heal. Those caries which happen from the matter of abscesses lying too long upon the bone, are most likely to recover: those of lues venerea very often do well, because that distemper fixes ordinarily upon the middle and outside of the densest bones, which admit of exfoliation; but those produced by scrophula, where the whole extremities of the spongy parts of the bone are affected, are exceedingly dangerous.

64
Of carious
ulcers.

65
Treatment.

The method of treating an ulcer with caries, is by applying a caustic of the size of the scale of the bone which is to be exfoliated; and after having laid it bare, to wait till the carious part can without violence be separated, and then heal the wound. In order to quicken the exfoliation, there have been several applications devised; but that which has been most used in all ages, is the actual cautery, with which surgeons burn the naked bone every day, or every other day, to dry up, as they say, the moisture, and by that means procure the separation: but as this practice is never of great service, and always cruel and painful, it is now pretty much exploded. Indeed, from considering the appearance of a wound, when a scale of bone is taken out of it, there is little doubt that burning retards rather than hastens the separation; for as every scale of a carious bone is flung off by new flesh generated between it and the sound bone, whatever would prevent the growth of these granulations would also in a degree prevent the exfoliation; which must certainly be the effect of a red-hot iron applied so close to it.

Some caries of the bones are so very shallow, that they crumble insensibly away, and the wound fills up; but when the bone will neither exfoliate nor admit of granulations, it will be proper to scrape it with a rugine, or perforate it in many points with a convenient instrument down to the quick. In scrophulous cases, the bones of the carpus and tarsus are often affected; and from their sponginess they are seldom cured: so that when these, or indeed the extremities of any of the bones, are carious through their substance, it is advisable to amputate; though there are instances in the scrophula, but more especially in critical abscesses, where, after long dressing down, the splinters, and sometimes the whole substance, of the small bones, have worked away, and a healthy habit of body coming on, the ulcer has healed; but these are so rare, that no great dependence is to be laid on such an event. The dressings of carious bones, if they are stinking, may be doffils dipped in the tincture of myrrh; otherwise those of dry lint are easiest, and keep

down the edges of the ulcer better than any other gentle applications.

White
Swellings.

SECT. II. Of White Swellings.

THERE are two species of white swellings, Mr Benjamin Bell observes; the one of a mild nature, and frequently admitting of a cure; which the other never does. The former, named by our author the *rheumatic* species of white swelling, begins with an acute pain, seemingly diffused over the whole joint, and frequently extending along the tendinous aponeuroses of the muscles which communicate with it. There is, from the beginning, an uniform swelling of the whole surrounding integuments. Great tension generally prevails; but at first there is seldom any external change of colour. From the commencement of the disease the motion of the joint is attended with exquisite pain, and the patient keeps it constantly in a relaxed posture, finding that the easiest. Hence the tendons become extremely stiff and rigid, till at last the joints have the appearance of complete and real ankyloses. The swelling now begins to augment, till the joint has acquired three or four times its natural size; the cuticular veins become turgid and varicose; at the same time that the muscular substance of the limb below decays, though it frequently acquires an equality in size by becoming oedematous; the pain becomes intolerable, especially when the person is warm in bed or otherwise heated; abscesses form in different parts, which, either breaking of themselves, or by being laid open, discharge considerable quantities of matter, but without any remarkable effect in reducing the size of the swelling. The pus discharged from these is at first of a tolerably good consistence, but soon degenerates into a thin ill-conditioned sanies. However, the orifices from whence it flows soon heal up, unless they are kept open by art; and new collections breaking out, they burst and heal up as before; so that in long-continued disorders of this kind, the surrounding integuments are often entirely covered with cicatrices.

In the mean time, the health of the patient gradually declines, from the violence of the pain, and the absorption of matter into the system, which takes place in some degree from its first formation in the different abscesses; but which never appears so evidently till the different abscesses have been laid open; after which a quick pulse, night-sweats, and a weakening diarrhoea, are sure to occur, which generally carry off the patient, if the member is not either amputated, or the disease cured some other way.

On dissecting limbs which have been amputated for white swellings, the original disease appears to have been a morbid thickening of the surrounding ligaments, without any other affection of the joint whatever; the bones and cartilages always remaining perfectly sound, as likewise the synovia both in quantity and consistence. In the more advanced stages of the disorder, the thickness of the ligaments is more considerable, and is generally attended with an effusion, into the surrounding cellular substance, of a thick glairy matter, which gives to swellings of this kind an elastic springy feel, independent of the collections of matter the fluctuation of which may also be perceived. Through this glairy matter the collections of pus run in various directions, without seeming, however, to mix with it. In some instances also a great many small hydatides are observed; all which form a confused mass, incapable of further dissection.

All the above-mentioned appearances have been observed without any affection of the bones or cartilages. But when, by a very long continuance of the disorder the ligaments come to be corroded by the different collections of

matter

White
Swellings.White
swellings.

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Scrophu-
lous white
swelling.

matter, the cartilages and in consequence thereof the bones, soon begin to suffer. The tendons of the flexor muscles, though very stiff and contracted, do not, upon dissection, show any signs of disease.

The above is an history of the mildest species of white swelling; the more inveterate kind our author names the *scrophulous white swelling*. In this the pain is commonly very violent; more acute than in the former; and, instead of being diffused, is confined to a particular spot, commonly the very middle of the joint. The swelling is commonly inconsiderable at first; inasmuch that, on some occasions, even when the pain has been very violent, little difference in point of size could be observed between the diseased and the sound joint. The motion of the joint is attended with very great pain, and the tendons become stiff. As the disorder advances, the pain becomes more violent, and the swelling increases, with an evident enlargement of the ends of the bones. The same elastic feel, together with similar abscesses, occur in this as in the last: but upon opening them they commonly discharge a thin fetid stuff; the bones are found to be carious, and pieces of them are frequently discharged at the openings.

By the continuance of the disorder, the constitution suffers, as in the first species of the disease; and a diarrhoea with night-sweats commencing, the patient is soon reduced to little more than skin and bone.

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Appearan-
ces on dis-
section.

Upon such joints being dissected in the first stages of the disorder, the soft parts seem very little affected: but there is constantly observed an enlargement either of the whole ends of the bones, or of their epiphyses; frequently of those on one side of the joint only; in others, again, the bones on both sides have been affected.

This enlargement sometimes occurs without any other evident disease: but in general, and always in a more advanced state of the complaint, the soft spongy parts of such bones appear dissolved into a thin, fluid, fetid matter; and that too, in some cases, without the cartilages which surround them seeming much affected. In process of time the cartilages are likewise dissolved; and then the matter of the bones and softer parts mixing together, such swellings exhibit in that state a still more confused collection than is generally observed even in the worst stages of the other species of the disorder.

In the farther progress of this disease the surrounding soft parts likewise suffer: The ligaments become thickened, and the contiguous cellular membrane is stuffed with the viscid glairy matter observed in the other species of the disorder.

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Causes of
this disease.

We come now to the consideration of the different causes which tend to produce this disease. That the ligaments of the joints only are first affected in this disorder is rendered evident by dissection. The thick glairy effusions into the cellular membrane are probably occasioned by an exudation from the vessels of those ligaments that have been originally inflamed, as such parts never furnish a proper fluid for the formation of purulent matter: In the course of the disease, indeed, abscesses containing real pus always appear; but never till inflammation has been communicated to the surrounding parts. We may conclude, therefore, that the first species of white swelling is always occasioned by an *inflammatory* or *rheumatic affection* of the ligaments of such joints as it attacks, from whatever cause such inflammation may originally have proceeded.

The other species of the disorder seems to be originally an affection of the bones; the surrounding soft parts coming only to suffer in the progress of the disease from their connection with and vicinity to these. This last species of white swelling generally begins without the patient being

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in the least able to account for it: and from the effects which it produces on the bones attacked, appears to be a species of *spina ventosa*; a disease of the bones probably of the same nature as scrophula is of the soft parts. Indeed, the appearances of the two disorders, after making allowance for their different situations, are exceedingly similar: they both begin with considerable enlargements or swellings of the parts, which generally end in ulcerations; they both likewise frequently occur in the same person at the same time. This species of white swelling is generally either attended with other evident symptoms of scrophula; or the patient, in an early period of life, has been subject to that disease; or, which is nearly the same, he is descended from scrophulous parents, and probably has the seeds of that disease lurking in his constitution. From all these circumstances, it may with probability be concluded, that this species of white swelling is of a scrophulous nature: and since the other species of the disorder is to be considered as an inflammatory affection, a thorough distinction between them is of very great importance; it will not be improper therefore to give a short enumeration of the several diagnostic or most characteristic symptoms of each.

The pain in the first species is always, from the beginning, diffused over the whole joint, and sometimes extends a considerable way along the muscles that are attached to it: in the other species it is always at first, and sometimes even when the complaint has been of considerable standing, confined to a very small circumscribed space. In the former, the swelling is always confined to the soft parts, and is from the beginning exceedingly evident: but in the latter, it is generally for some time hardly perceptible; and when it appears the bones are the parts chiefly affected, the surrounding teguments coming only to suffer on a farther progress of the disease. These are the chief local differences of the two species of this disorder; but some assistance in the distinction may likewise be obtained from the general habit of the patient, and from the manner in which the complaint may seem to have been produced. Thus, when such swellings occur in young, strong, plethoric, people, especially in such as have formerly been subject to rheumatism, they most probably will always prove of the mildest or rheumatic species of the disorder: But when they appear in patients of scrophulous dispositions, we need be under very little doubt in concluding them to be of a scrophulous nature.

The great utility of properly distinguishing the two different species of white swellings appears in no circumstance so evident as in the treatment. In the one, there being some chance, by proper remedies, of being serviceable to the patient; whereas in the other, viz. the scrophulous, it is not probable that art will ever be able to afford much assistance.

In the rheumatic white swelling, as it is always at first evidently of an inflammatory nature, considerable advantages are commonly obtained by a due attention to a proper cooling course. The first remedy which, with this view, should be put in practice, is blood-letting immediately from the part affected. Cupping and scarifying is here a principal remedy. The instrument should be applied to each side of the diseased joint; on each side of the rotula, for instance, when the knee is the part affected, and at least eight or ten ounces of blood discharged; and this to be repeated at proper intervals, once, twice, or oftener, according to the violence of the symptoms and state of the patient's strength at the time.

Cupping is, in these cases, much superior to leeches, because it is more expeditious, and because of the swelling occasioned by the application of any considerable number of these

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Treatment
in the rheu-
matic white
swelling.

White
Swellings.

these animals proves frequently very troublesome, and sometimes interrupts for a time the use of other remedies.

Upon the anterior part of the joint, where the cupping-glasses have not been placed, a small blister should be directly applied, and the part kept open with issue ointment, till the wounds from the scarificator are so far healed that a vesicatory may likewise be laid on one side of the joint; and so soon as that is nearly healed, the other side should be also blistered. By thus alternately applying them, first to the one side and then to the other, almost a constant stimulus is kept up; which, in deep-seated inflammations, seems to have fully a greater influence than all the discharge occasioned by blisters. Gentle cooling laxatives at proper intervals are also of use; and the patient should, in every respect, be kept upon a strict antiphlogistic course, both as to diet and every other circumstance.

It is in the first stages only of the disease that such a course can be of much service; and in such it has frequently been a means of curing disorders which otherwise might have proceeded to the last stages of white swellings.

The original inflammatory affection being once over, these sort of drains seem to have little or no influence, and ought not then to be long persisted in, as they prevent the use of other remedies, which, in an advanced state of the disease, are commonly more efficacious.

The inflammation being mostly gone, and while there are yet no appearances of the formation of matter, mercury has sometimes been known of use; not given so as to salivate, but merely to affect the mouth gently, and to keep it somewhat sore for a few weeks.

The best form of using it is by way of unction, as it allows, at the same time, the application of friction; which, in all such swellings, may of itself be in some measure considered as a remedy. For this purpose, an ointment of quicksilver and hog's lard should be prepared; but with so small a proportion of the former, that the patient may admit of two drams of the ointment being rubbed in three times a-day. In order to rub that quantity of the medicine in with gentle friction, an hour each time is at least necessary; for in the ordinary way of continuing friction for a few minutes only, it can seldom have much influence.

By Le Dran, and other French writers, falls of warm water on swellings of this nature are much recommended; and there is no doubt, that a long continued and reiterated application of that remedy may, in the first stages of such complaints, be often attended with very good effects. By a proper use of these different applications, viz. of the several topical remedies in the first or inflammatory state of the disease, and afterwards (still, however, before the formation of matter) of mercurials, friction, &c. many affections of this nature have been entirely removed.

It frequently happens, by the bent position the limb has been for a long time kept in, that the use of the joint comes to be entirely lost, having often acquired such a degree of stiffness, that any attempts to move it are commonly attended with very great pain. This has been constantly attributed to one or other of two different causes, which are both in their nature incurable, viz. either to the ends of such bones as compose the joints having run into one another, so as to become firmly conjoined in consequence of the surrounding cartilages being abraded; or to the inspissation, as it is termed, of the synovia of the joints, whereby their cavities are entirely filled up, and no space left for the future motion of the bones.

Both these opinions, however, are in general very ill founded: as the stiffness almost always proceeds from a contraction of the muscles and tendons. It may often be cured by a long continued use of emollients.

The best emollient that can be used is pure olive oil applied warm; as much of it as can be easily rubbed in by an hour's gentle friction should be regularly done at least three times a-day; and instead of confining the friction altogether to the rigid tendons, it should be extended over the whole muscles, even to the insertions of their other extremities; but more especially on their fleshy muscular parts, where the principal cause of the continuance of such complaints is probably seated.

The web or omentum of a new-killed sheep, or of any other animal, applied over all the diseased parts directly on being cut out of the animal, is sometimes attended with advantage. The application should be renewed as frequently as possible, once a day at least, or oftener when it can be done; for on being more than four or five hours applied it becomes disagreeable; and after that time, indeed, as it commonly turns stiff, it cannot then probably be of much service.

The disorder has hitherto been supposed not to be so far advanced as to have occasioned the formation of matter; ⁷² *gery.* for when come that length, no considerable advantages can be expected from any of the remedies as yet recommended; but even in that state of the complaint, if the patient's health does not absolutely require it, amputation of the member ^{When am-} should not be immediately had recourse to. ^{putation} For by opening ^{should be} the different abscesses soon after their formation, the mat- ^{performed} ter may be prevented from destroying the capsular ligaments of the joints, which, if once effected, would no doubt render that operation necessary. Even in point of success from the operation, it ought never to be advised till the complaint is pretty far advanced. For in this disorder, especially, a greater proportion of patients have recovered after amputation, who have previously been considerably reduced by diarrhoeas and other weakening symptoms, than of such as have still remained in a full plethoric habit of body."

All the different observations hitherto made upon the treatment, relate particularly to the rheumatic species of the disorder; and when had recourse to in time, and duly persisted in, they will frequently be found of service: but when the disease is so far advanced as to have destroyed the capsular ligaments of the joint, and perhaps even the cartilages and bones themselves, amputation of the member is then no doubt the only resource.

In the scrophulous white swellings, when the diseased parts of the bone begin to cast off, a cure may in that way, by assisting the efforts of nature, be sometimes obtained in the small joints; but in all the large joints, as the knee, ankle, &c. it is not probable that any other resource than amputation will ever afford much relief. And even the effects of that operation can seldom be depended on as lasting; for when the general scrophulous taint still subsists in the constitution, the disorder will most probably appear again in some other part; which, however, in the advanced stages of the disease, it is sometimes necessary to run the risk of, the pain being often so tormenting as to make it more eligible to submit to any hazard rather than to bear it longer.

When, however, for some reason or other, amputation is determined against, as there being almost a certainty of the complaint soon returning, from the scrophulous disposition appearing very strong in the system, it then becomes necessary to have recourse to palliatives, so as to render the complaint as tolerable as possible: and with this view, opiates in large doses, by moderating the pain and procuring rest to the patient, will in general be found the principal remedy. In other respects, all such medicines and articles of regimen as are found beneficial in scrophula, may be had recourse to.

SECT. III. Of Cancers.

CANCERS most commonly arise in the glandular parts of the body, where they are occasioned by any bruise or contusion, sometimes a very slight one: and hence they are more common in the lips, and in the breasts of women, than in any other parts of the body. Cancers have been generally distinguished into *occult* and *open*. By the former are meant such hard scirrhus swellings as are attended with frequent shooting pains, and which at last generally terminate in the latter.

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Appearances of an ulcerated cancer.

By the *open cancerous ulcer*, is understood that species of sore which commonly succeeds to hard swellings of the glands; although in some instances it occurs without any previous hardness. The edges of the ulcer are hard, ragged, and unequal, very painful, and reverse in different ways, being sometimes turned upwards and backwards, and on other occasions inwards. The whole surface of the sore is commonly very unequal, there being in some parts considerable risings, and in others deep excavations. The discharge, for the most part, is a thin dark-coloured fetid ichor; and is often possessed of such a degree of acrimony as to excoriate, and even destroy, the neighbouring parts. In the more advanced stages of the disease, by the erosion of blood-vessels which occurs, considerable quantities of pure blood are sometimes also discharged.

Patients labouring under real cancerous affections universally complain of a *burning* heat over the whole ulcerated surface; which, in general, is the most tormenting symptom that attends the disorder; and those shooting lancinating pains, which were troublesome in the more occult state of the complaint, become now a great deal more so.

These are the most frequent symptoms which attend an ulcerated cancer; but the appearances of such sores are so various, that it is almost impossible in any description to comprehend every one. When two, three, or more, however, of those enumerated, concur together in the same ulcer, we may always be pretty certain of its being of the cancerous kind.

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Causes of cancer.

Concerning the causes of cancers, there have been a great many conjectures, but without any solid foundation. It is of some moment, however, to determine whether they arise from some general disorder in the system, or whether they are only to be accounted local diseases. Many of the most eminent practitioners have been of opinion that they arise from a general disorder of the system; and hence consider them as totally incurable even by extirpation, as the latent seeds of the disease, in their opinion, will not fail to bring on a return of it somewhere or other. Of this opinion the late Dr Monro appears to have been; and in a paper on this subject in the *Edinburgh Medical Essays*, declares, that "of near 60 cancers which he had been present at the extirpation of, only four patients remained free of the disease at the end of two years." From this bad success, and the violent progress of the disease, he finally concludes against the extirpation of cancers, and proposes only the palliative method of cure. But later practitioners have been a great deal more successful; and a late publication by Mr Hill, surgeon at Dumfries, has put the usefulness of extirpation beyond a doubt, when the operation is performed in time: though, after the disease has continued long, and the virus been absorbed, the whole system acquires a cancerous disposition, and the disease almost certainly recurs in some other part. From internal medicines we can expect little or nothing in the cure of cancers; and external applications can do no more than palliate. Great expectations were formed from the powder and extract of cicuta; but it has so universally failed, that few put much confidence in it at pre-

sent. However, it has sometimes been of service in cases of a simple indurated gland; and even where the disease has been farther advanced, it has produced a better discharge, and diminished the fetor of the sore; but as it cannot be depended upon for a radical cure, a delay of the operation is never to be recommended.

Cancers.

No part of the body is more subject to cancer than the breasts of women. Cancer of the mamma may arise at any period of life, though it seldom appears till about the time the menses usually disappear. Tumors arising in the breast previous to this period have been considered by some practitioners as being only of a scrophulous nature; and it is probably owing to that circumstance that several cures have been of late years made on tumors of the breast by mercurial frictions and other remedies.

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Cancer of the mamma.

Scirrhus and cancer of the breasts are distinguished by the following marks: When the tumor is first observed, it is commonly in form of a small hard knot in the glandular part of the mamma, while the skin at the same time is free from inflammation. It frequently continues in this state for several months: by degrees, however, it increases considerably in size, and at last a sharp pain is felt shooting towards the axilla. The lymphatic glands at the under edge of the pectoral muscle and in the axilla are often enlarged, and an occult cancer is now formed. By degrees the integuments over this part of the tumor in the mamma become discoloured, and at last an ulceration or open cancer breaks out. Violent hemorrhagies now frequently ensue; the pain becomes still more excruciating; and, unless proper assistance be given, the patient is generally cut off in not many months after the breaking out of the cancer.

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its symptoms.

In early stages, the disease in general may be considered as entirely a local affection, and a radical cure may be of course expected; but in proportion as the skin shall afterwards be found diseased and adhering to the gland, and that to the pectoral muscle, and the lymphatic glands near the mamma and in the arm-pit swelled, the chance of a cure becomes more doubtful, as the cancerous matter may have been absorbed, and part of it carried into the system. The most unfavourable state for an operation is when there are ulcerations in the breast, large, deep, and of long standing; and particularly if these are attended with great pain, when the arm of the affected side has become oedematous, and the health of the patient is much impaired. In this last state very little is to be expected from a surgical operation.

In extirpating the mamma, which we shall first suppose is to be done where the skin is sound, and where the tumor has no uncommon adhesion to the pectoral muscle, the patient ought to be placed horizontally in a bed, or upon a table covered with a mattress, &c. The operator is to be seated, and to have proper assistants. A longitudinal incision is then to be made with a common scalpel through the skin and cellular substance along the whole extent of the tumor, and at a little distance from the nipple, which is to be saved. When the longest diameter of the tumor is across the body, instead of a longitudinal incision, a transverse one is to be made. The integuments being dissected from the mamma on both sides of the incision, the patient's arm is to be extended to save the pectoral muscle; and the whole glandular part is to be detached from the muscle, though a small portion only should be diseased, beginning at the upper side, and separating downwards. If there be any indurated glands, they are to be carefully removed. If the patient be faint, a glass of wine, or some other cordial, is to be given. After the diseased parts are removed, the wound is to be cleaned with a sponge wrung out of warm water, which will generally render the small bleeding vessels more conspicuous. The integuments are next to be closely applied

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Method of extirpating the mamma.

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Cure.

Cancers. plied to the parts underneath, and retained there by the twisted future, and likewise by a few adhesive straps. A large pledgit of simple ointment is now to be laid over the whole; and this is to be covered with a thick compress of lint, tow, or soft linen; and the dressings to be kept in their place, and moderate pressure made by the napkin and scapulary bandage.

By this method the integuments will generally soon adhere, and a cure will be performed by the first intention. But it does not often happen that the operation is performed while this favourable mode of practising it will answer.

In general, before extirpation of a breast is recommended by the surgeon, or submitted to by the patient, a considerable portion of the external integuments are so much diseased as to render it necessary to separate them along with the glandular part of the mamma. It sometimes happens likewise that the tumor adheres to the pectoral muscle, and that again to the ribs. In either of these cases it becomes necessary to remove all the diseased parts. For this purpose, two incisions of an oval form, with sharp extremities, of a sufficient size to include the whole of the affected parts, become necessary. If again it be found, that besides the disease of the breast, the lymphatic glands in the neighbourhood are indurated, or otherwise diseased, the first incision ought to extend at once over these; and after the other parts have been removed, and the vessels secured, the whole of the diseased glands are to be extirpated; and in performing this part of the operation, considerable assistance may be given by supporting them with a hook, or a ligature passed through them, till they are entirely removed. When they lie deep in the axilla, the points of the fingers, or the end of the handle, will sometimes be safer than the edge of the knife. After having removed all the glands which are in the smallest degree affected, the cut edges of the skin are to be brought as near to each other as the nature of the case will allow, so as to heal as much as possible by the first intention. After the wound is nearly, or perhaps entirely healed, an issue, inserted into the arm of the opposite side, will be the best means of preventing a relapse.

SECT. IV Burns.

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Consequences of burns. THE immediate consequence of burns is a greater or less degree of inflammation; and the danger attending such accidents is in proportion to the extent of the injury. Burns which irritate the skin only, without destroying the cuticle, act nearly in the way of a common blistering plaster. When the cuticle is destroyed, no blister takes place; a mortified slough is observed; and when this separates, an ulcer is left. Where the cuticle is not destroyed, relief may be procured by holding the part affected a considerable time in very cold water, or sometimes by plunging it two or three times into water a little below the boiling point. Solutions of saccharum saturni, and other preparations of lead, have been recommended, as in the case of other inflammations. Vinegar is found a very effectual application, whether the skin be sound or blistered. The part may be entirely immersed in it, or linen rags dipt in the vinegar may be applied, and the parts kept constantly moist, till the pain be removed. The same application is useful where the skin is rubbed off, or otherwise destroyed. In this case, indeed, the vinegar is apt to give additional pain on its first application; but this soon ceases, and the part becomes much cooler and easier. If the patient will not suffer the vinegar to be applied immediately to the surface of the sore, a linen rag soaked in olive-oil may be previously laid on the part, covering the whole with the cloths dipped in vinegar; and these applications are to be occasionally repeated till

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Cure.

the pain and inflammation be entirely removed; after which the parts are to be dressed in the same manner as in the case of a common blister. In extensive burns, where the irritation is great, along with external applications, opium should be prescribed, in doses adequate to the degree of pain. Even that stupor with which patients in this situation are sometimes attacked, is found to be more readily removed by opium than by any other remedy. With respect to the blisters which arise upon burns, it has been disputed whether they ought to be opened, or allowed to remain till they dry up of themselves. But, according to the opinions of the latest authors, they ought to be opened as soon as any considerable quantity of fluid is found in them. After the serum is discharged, a thin liniment of wax and oil, with a little saccharum saturni, should be applied to the part.

In cases of very severe burns, where, notwithstanding the above treatment, there is danger of a violent inflammation being induced, blood-letting, cooling purgatives, and other remedies adapted to the peculiar symptoms, must be used. When, again, burns are from the first attended with loss of substance, as commonly happens after the application of hot metallic bodies, we ought to have recourse to the vinegar, as already mentioned, or to a liniment which is now in very common use for such purposes, made of equal parts of lintseed oil and lime-water, which, when shaken together, forms a thick white substance, which often gives speedy relief; and it may be readily applied by daubing the parts frequently over with a soft pencil well soaked in it. Though this has been considered as one of the best applications in burns, yet, in some cases, more immediate relief has been procured from the application of Goulard's cerate, or the unguentum nutritum; and a weak solution of saccharum saturni has sometimes been of service.

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Burns occasioned by gunpowder. When burns are occasioned by the explosion of gunpowder, some of the grains of the powder are apt to be forced into the skin. At first they produce much irritation; and if they are not removed, they commonly leave marks which remain during life. They should, therefore, be picked out as soon as possible after the accident; and to prevent inflammation, as well as to dissolve any power which may remain, the parts afflicted should be covered, for a day or two, with emollient poultices. In other respects, injuries of this sort are to be treated like any other kind of burns.—When burnt parts are contiguous to each other, they are apt to adhere. To prevent this, pledgits covered with any proper dressing ought to be inserted between them during the course of the cure. Ulcers arising from burns are apt to become soft and fungous, and to rise above their natural level. When this is observed, the emollient ointments, which may have been previously used, should be laid aside, and those of a moderately astringent nature applied. Gentle compression with a roller is also of particular service. Advantage is likewise derived from saturnine washes, &c. One of the best ointments, in such cases, is the common calamine cerate. These will commonly answer the purpose; but when they prove insufficient, burnt alum, blue vitriol, or even lunar caustic, may be necessary.

CHAP. V. Of Inflammatory Tumors.

INFLAMMATORY TUMORS are such as are quick in their progress when compared with those of the indolent kind, and are attended with considerable pain and other symptoms of inflammation. We have here mentioned such only whose treatment more properly belongs to the province of the surgeon, and which are placed according to their situations in the different parts of the body.

Inflam-
matory
Tumors.

SECT. I. *Inflammation and Abscess of the Breasts of Women.*

THIS disorder occurs most frequently in nurses by the stoppage of the milk, which is always occasioned by sudden or imprudent exposure to cold.

In the early stages of the affection, resolution is always to be attempted, unless the swelling appears to have an evident tendency towards suppuration. The remedies used in inflammation, in general, seem useful in every case of inflammation of the breasts. When the patient happens to be nursing, a sudden evacuation of blood is apt to diminish the quantity of milk: In such cases, therefore, blood is to be extracted in small quantities at a time. The application of cooling saturnine poultices is advisable. When suppuration has taken place, the matter is to be discharged by making an incision in the most depending part of the tumor.

SECT. II. *Inflammation of the Testicles.*

THIS disease is often owing to exposure to cold, violent exercise, &c.; but most frequently to gonorrhœa virulenta, and never to matter falling down upon the testes, as was supposed by those who gave it the name of *hernia humoralis*. Inflammation here rarely terminates in suppuration.

The best method for discussing the inflammation is by the application of leeches; after which the penis ought to be kept constantly moistened with a solution of saccharum saturni, and the scrotum and testes supported by a proper bandage. The bowels should be kept moderately open; the patient should use a low diet, and keep as much as possible in an horizontal posture. If lues venerea be present, a cure cannot be expected without mercury. If the disease is owing to a sudden stoppage of the discharge in gonorrhœa, the running ought to be restored, and promoted by bathing the penis in warm water, injecting warm oil, and the use of bougies. These means will generally discuss the inflammation. If matter form, it must be discharged.

SECT. III. *Of Venereal Buboës.*

A SWELLING of any of the lymphatic glands of the body is called a *bubo*; and when such a swelling proceeds from venereal poison, it is termed *venereal bubo*. They seldom or never appear except in the lymphatic glands of the groin, arm-pit, or extremities, and much more frequently in the groin than anywhere else.

In the treatment of buboës, a strict antiphlogistic regimen is to be used to promote a resolution; the application of leeches to the hardened gland is particularly proper. In discussing venereal buboës, the application of mercurial ointment has a considerable effect. After suppuration is completely formed, the application of caustic to open the bubo is dangerous, lest it should corrode some of the considerable blood-vessels, which generally lie contiguous to the bubo. Buboës, when opened by the knife, are said to heal with more difficulty, and generally to leave a scar behind them. To allow them to burst of themselves, is therefore for the most part proper, except when the collection is so considerable as to press upon the neighbouring blood-vessels. In such a case, a small incision may be made by the lancet, taking as much care as possible to prevent the admission of the external air into the wound. When the edges of the opening grow callous, the application of lunar caustic to them becomes necessary. During the remaining part of the cure, mercury joined with opium is to be used.

SECT. IV. *Lumbar Abscess.*

THE term *lumbar* may be applied to every abscess seated in the loins; but that which is here meant is such as be-

gins about the top of the os sacrum, and is seated in the vicinity of the great psoas muscle.

The symptoms begin with pain and tension about the loins, shooting upwards to the spine and downwards to the thigh. The disease has sometimes a strong resemblance to nephritic affections, and is sometimes mistaken for lambago. After suppuration takes place, shivering fits come on; and the pain now becoming dull, the patient imagines himself better, till matter points at the side of the anus, or in the groin. The first case is rare; and when it does occur, the tumor bursts, or is opened as a common abscess. In the other case, the matter is seated behind the fascia of the groin, and sometimes descends as far as the knee. The teguments commonly retain their natural appearance. Fluctuation is evident, especially when the patient is in an upright posture. It is often mistaken for crural hernia; but may be easily distinguished from it, by its slow progress, by pain in the lumbar region at the commencement of the disease, by the patient allowing the tumor to be handled freely, by fluctuation being evident, by the tumor becoming flaccid when the patient is in an horizontal situation, and by the absence of all the symptoms by which hernia is distinguished. Both diseases may occur at once; but this is very rare, and a distinction is still to be made.

It is discovered that this disease has, in general, been induced by considerable injury being done to the small of the back or loins, either by twists, or severe bruises, or by sudden exposure to cold after the heat occasioned by severe exercise, particularly in scrophulous habits. Were accidents of this nature immediately treated with that attention which their importance deserves, the disease might frequently be prevented.

In the treatment the strictest antiphlogistic regimen ought to be observed. Blood-letting ought immediately to be performed, by scarifying deeply and leeching the injured part: neither are blisters, opiates, gentle purgatives, and other remedies useful in inflammations, to be neglected.

Authors have an idea that little advantage can be derived from laying open the abscess, on account of the great danger which may ensue from the admission of air. Mr. Benjamin Bell, however, is of an opposite opinion, and has always given vent to matter here as elsewhere, and no bad consequences have been observed. The matter, when long lodged, has been found to destroy the soft parts and bones, and sometimes to make its way into the cavity of the abdomen; all of which might be prevented by an early evacuation. For this purpose a trocar should be used, which was tried by Mr. Bell in one case with complete success.

Some other cases are lately narrated by authors, where, by the introduction of a seton, and drawing off the matter by slow degrees, and then by using compreses, and sometimes injections of gently irritating fluids, a cure has been performed in the course of a few months. If the case is doubtful, an opening should be made with the knife in the same manner as in hernia. If the flow of matter continue considerable for the space of two or three weeks, injections of a weak solution of saccharum saturni, lime-water, or other gentle astringents, may be employed.

SECT. V. *Paronychia or Whitloe, and Chilblains.*

WHITLOE is a painful and inflammatory swelling at the extremities of the fingers under the nails, terminating in an effusion of clear serum below the skin, which is sometimes so acrid as to corrode the periosteum, and render the bones carious. At other times the inflammation runs so high that the whole of the arm swells, particularly the lymphatics, and sometimes even the glands in the axilla.

When this affection arises from external violence, the re-

medie

Inflamma-
tory
Tumors.

medies employed for inflammation, in general, will be of service. When it arises from unknown causes, ardent spirits and astringents have been found useful, particularly when topical and general bleedings have been previously used. When an effusion of a serous matter takes place, it is immediately to be discharged, as it is almost impossible to convert it into proper pus. When this serum has continued so long as to render the bone carious, a removal of the whole bone, or of the carious portion, becomes necessary, in order to effect a complete cure.

86.
Chilblains.

Chilblains are inflammatory swellings, of a purple colour, chiefly affecting the heels, and sometimes also the fingers, toes, arms, hands, or feet, or even the tips of the nose and ears, attended with a stinging pain, and a degree of itching. The swelling sometimes cracks, and discharges an acrid serum: sometimes a mortification takes place, and an ulcer follows very difficult to heal.

This disorder is owing to the weaker action of the small vessels most remote from the heart, occasioned by cold or dampness, and occurs most frequently in people of a delicate constitution.

When the patient has been for some time exposed to the cold, and the parts are frost-bitten, they ought to be plunged into the coldest water and rubbed with salt; when they are only benumbed, rubbing them with camphorated spirit of wine will answer equally well: but when cracks take place, and an oozing of acrid matter ensues, poultices may be applied, but not long, as they are apt to give rise to fungous excrescences.

SECT. VI. Of Contusions and Sprains.

87.
Symptoms
of contu-
sions and
sprains.

CONTUSIONS of the integuments and muscles produce pain, swelling, and inflammation, and these, in some cases, may extend to a considerable degree; but in general they are less violent than what take place in cases of sprains of ligaments or tendons; for in these there is frequently a total loss of motion for many weeks, and sometimes for years, if proper attention be not paid. An effusion of fluids always succeeds the injury, which seems to be, for the most part, of a serous nature, as the skin usually retains its natural colour; sometimes the tumefied parts are of a deep red, or leaden colour, owing to a rupture of some vessels conveying red blood.

88.
Treatment.

In the treatment of contusions and sprains, two circumstances require attention. 1. To endeavour to prevent the swelling as far as is practicable; 2. To employ those remedies afterwards which are known to be most powerful in preventing or removing inflammation. In contusions of the cellular substance, and even of the muscles, the effused fluids are commonly soon absorbed; but in sprains of the tendons or ligaments, a very troublesome, painful thickness of the injured parts is apt to continue for a great length of time, and in some instances even for life.

It is necessary, therefore, to obviate these symptoms as soon as possible; and for this purpose, cold astringent applications, as water, vinegar, &c. are most commonly used. Others again, with a view to relax the parts fully, make use of water as hot as the patient can bear it. By immersing the injured part in these immediately after the injury is received, the effusion will at least be somewhat obviated. When the pain is excessive, opiates become necessary.

After blood has been freely discharged, a repetition of the remedies already mentioned will be found to give great relief; care should be taken, at the same time, that the injured parts be kept in a relaxed and easy posture.

CHAP. VI. Of Indolent Tumors.

THESE are such as are slow in their progress, and may

continue for a long time without being attended with either pain or inflammation; though occasionally almost all of them may be inflamed, and some of them, in that state, attended with considerable pain. They are of different kinds according to the nature of their contents, and appear in various parts of the body. They are seated in the adipose and cellular membrane; whence it often happens that they take place in the viscera themselves, where they are frequently mortal. Sometimes they are filled with a substance of the consistence of honey, and are thence called *meliceratous* tumors; sometimes they are filled with a harder substance, and are then called *atheromatous* tumors; at other times they are filled with a substance of the consistence of fat, and are then called *steatomatous*. Sometimes, however, they are found to be replenished with a fluid lymph coagulable by heat, and are then called *hydatids*. One set are filled with matter like the synovia of the joints, and get the name of *ganglions*.

Tumors of this kind are easily distinguished from all others, as having neither heat, pain, nor pulsation, as is to be observed in those which incline to suppurate; and they are distinguished from each other, before they are laid open, by fluctuation being readily perceived in the meliceris: the atheroma is soft and compressible, but has no fluctuation; while the steatoma is commonly firm and rolls under the skin. But these rules are liable to considerable exceptions. The meliceris and atheroma are most commonly found upon the head, and the steatoma upon the other parts of the body; while ganglions are situated over the tendons of the muscles. These tumors must be either extirpated entirely, or laid open so as to dispose the cyst to slough off or granulate. If the matter be fluid, we may evacuate it by an opening made with a lancet, or by means of a seton; but as the matter is apt to collect again, it is better to remove the sac entirely. If large vessels or nerves prevent this from being done, then it is to be laid freely open and exposed to the air, so that the bag may granulate, or be thrown off. When the tumor is to be extirpated, a longitudinal incision is to be made through the integuments; after which the tumor may be frequently removed by the point of the finger, or by the end of a spatula, replacing the integuments with a view to heal by the first intention. In every pendulous tumor of this kind, with a narrow neck, we ought to divide the teguments near the bottom of the tumor, in an oval form, so that the wound may be afterwards properly covered with the remaining integuments. After the tumor is removed, the skin is to be replaced over the wound, and fixed with adhesive straps, covering it with a pledget of cerate, a small compress of linen, with a bandage above all, to make a gentle pressure on the parts.

SECT. I. Of Steatomatous and Sarcomatous Tumors.

STEATOMATOUS tumors have been ranked by authors among those of the encysted kind; but they have no other cyst containing them than the common cellular substance, somewhat condensed; and the particles of fat composing them are found of the same size with those in a sound part of the body.

Authors formerly advised the discussion of steatoma, or the prevention of their growth, by the application of pressure; but by such means the growth is rather promoted than retarded, nor have internal remedies been of any advantage. They can be removed therefore by an operation which is the same with that for the extirpation of encysted tumors.

Sarcomatous tumors have nearly the same external appearance with those of the steatomatous kind. The term has been applied, in a general way, to scirrhi of the glands;

but

Ganglions, but farcomatous tumors are likewise found in various other parts of the body, and are distinguished from steatoma by being firmer to the touch; internally they are found of a redder colour, or approaching that of muscles, in consequence of the greater number of vessels entering into their substance. These are to be treated in the same manner as steatoma; but the operation ought to be performed early, as they are more apt to degenerate into cancer.

SECT. II. *Of Ganglions, or Swellings of the Bursa Mucosa.*

GANGLIONS of the tendons are likewise tumors of the encysted kind, seated in the bursa mucosa, or sheaths of the tendons which belong to the extremities. They are most frequently met with over the tendons upon the back of the wrist, and often likewise about those of the ankle and other parts of the extremities. When pressed, they are found to possess a considerable degree of elasticity, from which, and from their situation, they may generally be distinguished from other encysted tumors. They seldom arrive at any great bulk, are not often attended with pain, and commonly the skin retains its natural appearance. On being laid open, they are found to contain a tough, viscid, transparent fluid, resembling the glaire of an egg.

They are generally produced by sprains, or contusions of the joints, or by rheumatism. In many instances, they go off insensibly, without any assistance from art; but as this is often not the case, means ought to be used for removing them. For this purpose, moderate friction frequently repeated, or gentle compression applied to them by means of thin plates of lead, &c. sometimes remove them. In some instances they have been removed by the application of blisters; but the most certain method is, to make a small puncture into the sac, and to draw a cord through it; or, after the puncture is made, to press out the contents, and then inject some gently stimulating fluid, as port wine and water heated blood-warm. Sometimes, in tumors of this kind, bodies of a cartilaginous nature, and of different shapes and sizes, are found; some quite smooth, others with peduncles; by which they are supposed by Dr. Monro, in his work upon the bursa mucosa, to have been attached to the bursa. As these cannot be removed by any remedy with which we are yet acquainted, it is found necessary to discharge them. But as the parts may sometimes suffer from inflammation when the tumor is laid fully open, it may be punctured at each end; and, after pressing out the contents, a small cord may be introduced; after which gentle pressure may be applied with a compress and bandage over the course of the tumor. The cord however should not be continued so long as to induce any great degree of inflammation, for it is found that a slight degree of this sufficiently answers the purpose.

SECT. III. *Of Collections within the Capsular Ligaments of Joints, and of Cartilaginous Bodies contained there.*

COLLECTIONS here may consist of serum, blood, or pus and synovia combined. They are most frequently met with in the joint of the knee, and may be produced either by internal or external causes. These kinds of collections may in general be distinguished from each other.

Watery effusions, commonly called *dropical* swellings of the joints, arise chiefly in consequence of severe rheumatic complaints; and when the tumor is not very large, the fluctuation of the fluid may be felt by pressure. When a large effusion appears immediately after a violent bruise, it is probable that it consists chiefly of blood: but when it succeeds a violent sprain, attended with great pain, inflammation, and swelling, terminating in an effusion, there is every rea-

son to think that the contained fluid consists of pus mixed with synovia.

Swellings of the joints are most apt to be confounded with collections in the bursa mucosa, or with matter effused in the adjacent cellular substance. From the first of these they are generally distinguished by the contained fluid passing readily from one side of the joint to the other, and from its being diffused over the whole of it; whereas, when it is contained in the bursa, the tumor is confined to a particular part, and is seldom attended with much pain.

When such collections can safely be allowed to remain, the capsular ligament ought never to be opened, as they can often be removed by discutients. Even considerable collections arising from rheumatism may commonly be discolled by friction, fomenting the parts with warm vapour, keeping them constantly moist with saturnine solutions, covering them properly with flannel, and applying blisters. When these fail, supporting the part with a laced stocking, or with a roller, has frequently been of service. But whether a rheumatic tumor can be discolled or not, it ought not to be opened; for the inconvenience attending it is more intolerable than the pain and inflammation which may ensue. But when the matter would do mischief by lodging, it should be discharged. Effused blood and matter which succeed high degrees of inflammation are of this kind. Blood is frequently extravasated among soft parts without much detriment; but when in contact with cartilage or bone, it soon hurts them materially. The matter ought to be discharged so as most effectually to prevent the admission of air into the cavity of the joint. For this purpose the opening should be made with a trocar; and the skin, previously drawn tight to the upper part of the tumor, should be pulled down immediately on withdrawing the canula. A piece of adhesive plaster should be directly laid over the opening, and the whole joint should be firmly supported by a flannel roller properly applied. If the patient be plethoric, he should be bled to such an extent as his strength will bear; he should be put upon a strict antiphlogistic regimen, and in every respect should be managed with caution; for inflammation being very apt to ensue, we cannot too much guard against it.

Joints are sometimes rendered painful and stiff by the formation of different substances within the capsular ligaments. These are sometimes loose, and as firm as cartilage; and sometimes of a soft membranous nature, similar to those already observed in treating of swellings of the bursa mucosa.

In some cases these substances, especially the last species, retain nearly the same situation, without being much affected either by pressure or by the motion of the joint: in that case the pain is constant, but seldom severe. The first species, however, is commonly very moveable; and on being touched, they slip with such facility that it is difficult to fix them even with the fingers. These are only painful in particular situations.

Where these concretions appear, upon examination, to be perfectly loose and detached, if the pain which they excite is very severe, we should venture in a cautious manner to take them out, by making an incision into the joint. But if there is reason to suspect that they are connected with any part of the joint, the patient ought to be advised to submit to the pain they induce, which in general will be rendered moderate by shunning exercise; but if, notwithstanding this, it becomes insupportable, amputation is the only resource.

The limb being firmly secured by assistants, in that posture which admits of the body to be taken out being felt most

Collections within the Capsular Ligaments of Joints, &c.

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97 Treatment.

98 Method of discharging the matter.

99 Concretions in the joints.

100 When perfectly loose, may be extracted.

101 Manner of extracting them.

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95 Causes of dropical swellings of the joints.

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within the
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of Joints,
&c.

most distinctly, the surgeon should endeavour to fix it with his fingers towards the upper part of the joint, after an assistant has drawn the skin as much as possible upwards from the part where the incision is to be made. The operator with a scalpel is now to make an incision through the teguments and capsular ligament, directly upon the substance itself, of such a size as will admit of its being easily taken out; which may be done either with the finger or with the end of a blunt probe. If it is found to be connected by any small filaments either to the capsular ligament or to the cartilages of the joint, they should be cautiously divided, either with a probe-pointed bistoury, or probe-pointed scissors, after drawing the substance itself as far out as it can be got. When more concretions than one are found, they should all be taken out at the same opening, when this can be done; but when it cannot, it will be better to allow the first incision to heal before attempting the second, so as to avoid as much as possible the exciting of inflammation.

After the concretion is removed, the skin should be immediately drawn over the wound in the capsular ligament; and the lips of the opening in the skin being laid together, they should be secured in this situation by pieces of adhesive plaster, so as to prevent the air from finding access to the cavity of the joint. Till the wound be completely healed, the patient should not only be confined to bed, but the limb should be kept as much as possible in one posture, and a strict antiphlogistic regimen should be preserved.

SECT. IV. Of Spina Bifida.

SPINA BIFIDA, is a tumor which sometimes appears upon the lower part of the spine in new-born children. A fluctuation is distinctly perceived in it, and the fluid it contains can in some measure be pressed in at an opening between the vertebræ. In some cases this opening is owing to a natural deficiency of bone; in others, to the separation of the spinous processes of the vertebræ.

The disease proceeds from serum collected within the coverings of the spinal marrow. It is always fatal. Children labouring under it have been known to live for two or three years; but, in general, they linger and die in a few weeks. All that art has been able to do is to support the tumor by gentle pressure with a proper bandage. When a tumor of this kind is laid open or bursts, the child dies in a few hours. A tumor nearly of the same nature with this is sometimes met with upon different parts of the head in new-born children: it is formed by a fluid lodged beneath the membranes of the brain, which have been forced out at some unossified part of the skull. What we have said with respect to the former is exactly applicable to this.

SECT. V. Of Scrophulous Tumors.

WE shall here only mention the surgical treatment of scrophulous tumors, having spoken of scrophula in general under the article MEDICINE. Some practitioners have recommended poultices, &c. to bring scrophulous tumors to suppuration; but the best practitioners have laid them aside, because they increase the soft and spongy state of the parts, by which they are prevented from healing.

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mors.

As external applications are ineffectual, it is better to allow scrophulous tumors to be as much exposed as possible, as this frequently renders the subsequent ulcer more easily cured. The other methods recommended for discussing these tumors are, the internal use of cicuta, burnt sponge, muriated barytes, a long continued use of the cold bath, particularly of sea-bathing, and drinking mineral or sea-water. These, to produce any effect, should be begun early, while the tumors are small, and long persisted in. When the tumors come to a state of suppuration, if they are seated up-

on the thorax or abdomen, or any of the large joints, free vent ought always to be given to the matter to prevent its bursting into these cavities; and when the abscess is large, this should be done with a trocar, or by passing a cord thro' it, in order to exclude the external air. When the tumors are not situated upon great cavities, it is better to allow them to break of themselves, as the sores commonly heal more readily, and the scar is pretty similar in both. The most proper applications to scrophulous sores seem to be those of the saturnine kind, as they diminish inflammation, and in some measure prevent the sore from spreading. When the bones become carious, they are to be treated like carious bones from other causes; but amputation cannot here be attended with advantage, as the disease proceeds from a fault in the constitution. After the sores are healed up, the introduction of an issue may assist in preventing their return.

Tumors of a scrophulous nature are sometimes apt to be mistaken for those of the scirrhus kind, and thus may be improperly extirpated. Scrophulous tumors deeply seated commonly have a degree of firmness, which, if they happen to be seated near a suspicious part, as close by the side of a woman's breast, may give occasion to such a mistake. But they may generally be distinguished by the softness even of the firmest kind of them, when compared with scirrhus. They have always a smooth equal surface; whereas scirrhus is somewhat unequal or knotty, and seated in the real substance of the gland; and a shooting pain is commonly felt in it from time to time, even from its first appearance. They are generally accompanied, too, with other symptoms of scrophula, which is not necessarily the case with scirrhus.

SECT. V. Of Bronchocele.

THIS is a tumor on the fore-part of the neck, seated between the trachea and skin, termed in French *goitre*. In this country it is very rare; but it is frequent among the inhabitants of the Alps, and other mountainous countries, and is supposed to be owing to the use of snow-water. It is seated most frequently in the thyroid gland; tho' in two cases examined by Mr Benjamin Bell this gland was diminished from the compression of the tumor, which was chiefly formed of condensed cellular substance, with effusions in different parts of it of a viscid brown matter. Dr Prosser considers bronchocele as a dropical affection of the thyroid gland; and in confirmation of this, he gives an account of a dissection of a diseased gland of this kind by Dr Hunter, who found in it a great number of capsules filled with water. The swelling is at first soft, without pain or any evident fluctuation, and the skin retains its natural appearance; but as the tumor advances in size, it becomes unequally hard; the skin acquires a copper colour, and the veins of the neck become varicose; the face becomes flushed, and the patient complains of frequent headaches, as well as of stinging pains through the body of the tumor.

Calcined egg-shells have been recommended by authors as a specific for this disease; but little dependence is to be placed on such a remedy. Frequent frictions are found useful, especially when employed early; saponaceous and mercurial plasters, too, have in some cases proved serviceable; and repeated blisters have been known to retard its progress. In the enlarged state of the tumor no remedy yet known is powerful enough to discuss it. When the disease is far advanced, the removal of the tumor by an operation must be attended with great danger, on account of the enlarged state of the arteries, as well as its vicinity to the common carotids. It is therefore thought by some of the most experienced practitioners, that in such a situation it would not be

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Nevi Materni, Corns, and Warts. be advisable to attempt extirpation, and that the patient should rather trust to the common palliative treatment. When the tumor, however, is not much increased, if other remedies have failed, and the disease is advancing, a surgeon might be warranted in attempting its extirpation.

SECT. VI. Of *Nevi Materni, Corns, and Warts.*

Nevi Materni are those marks which frequently appear upon the bodies of children at birth, and which are supposed to originate from impressions made on the mind of the mother during pregnancy. They are of various forms; their colour is likewise various; though most frequently resembling that of claret or red port-wine. Many of these marks are perfectly flat, and never rise above the level of the skin: these do not require the assistance of surgery; but in some cases they appear in the form of small protuberances, which frequently increase to a great size in the course of a few months. They appear to be firm and fleshy. They sometimes hang by slender attachments to the contiguous parts; but more generally they are fixed by broad bases. They may be removed with as little danger as any other tumor of the sarcomatous kind. They are supplied indeed more plentifully with blood than most other tumors are; and even sometimes they appear to be entirely formed by a congeries of small blood vessels; but the arteries which supply them may, for the most part, easily be secured by ligature. The operation should never be long delayed; for as the size of the vessels corresponds with that of the tumor, they sometimes are so large as to throw out a good deal of blood before they can be secured. In performing it, the tumor is to be cut out, the arteries taken up, and the remaining skin brought as well together as the nature of the part will allow, and kept so by adhesive plaster or suture. When the tumor is pendulous, and connected only by a narrow neck, it should be extirpated by ligature.

Corns are small hard tubercles, commonly situated on the toes or other parts of the feet, and sometimes on the hands. They are of a horny nature. They proceed from a diseased state of the cuticle, occasioned by pressure. The part becomes hard and thickened, with a small white substance in the centre, which has a disposition to become prominent. It likewise forms a depression in the subjacent cutis vera, and sometimes is said to penetrate it. When corns are situated on parts much exposed to pressure, they irritate the skin, and produce an increased sensibility of the part, and thus occasion much pain. The best preventative of corns is the wearing of wide shoes, and avoiding every kind of pressure; and unless this be attended to, it will be found difficult to keep free from them. Various remedies are recommended for the cure or removal of corns. One is to bathe the part about half an hour in warm water, then to pare as much off them as possible without giving pain, and to apply over them any emollient ointment. If this treatment be frequently repeated, while pressure from shoes is prevented, they generally fall off, and do not return if pressure be afterwards avoided. Another method is to allow them to grow to some length through pieces of perforated leather, properly secured by plaster or by any other means, and afterwards to cut round their root, by which they may for the most part be easily turned out. Or if such irritating substances be applied to them as will raise a blister by separating the cuticle from the cutis, the corn will be raised along with the cuticle, and may then be readily removed by a scalpel or scissors. The surface of the cutis being now exposed, is to be healed like any other part that has been blistered.

Warts are small, hard, indolent tumors, with a rough surface, appearing on different parts of the body, chiefly the

hands and face, and more commonly in young people. When they appear in advanced life they are apt to degenerate into cancer, especially when of a livid colour and with a smooth surface. If they do not prove troublesome, nothing should be done to them, as they generally either fall off or waste gradually away. When from their size or situation they require to be removed, this, if they are pendulous or have narrow necks, is easily done by ligature; but if their bases be broad, the scalpel or escharotic applications will be necessary. As few, however, will submit to the former, the latter are generally employed. Escharotics of a mild nature give least pain, and are least apt to excite inflammation, which in these cases it is difficult to remove, and are found to be quite sufficient for the purpose. One of the best of these is crude sal ammoniac: it should first be moistened in water, and then well rubbed upon the warts two or three times a-day. Liquid salt of tartar, and sometimes spirit of hartshorn, has answered the same purpose: some recommend also the juice of onions.

Warts appearing on the penis as a symptom of venereal infection, are of the same nature, and to be cured by the same means. Mercury is of no advantage here, and commonly indeed does harm. When every other part of the disease is eradicated, the warts may generally be removed by washing them morning and evening in lime-water, or in a weak solution of saccharum saturni. They may be removed also by the knife, and the parts from whence they are cut afterwards touched with lunar caustic, to prevent them from returning: but when this method is practised, the operator ought to be certain that he has removed the wart entirely, for where part has been left the most formidable symptoms have sometimes ensued.

SECT. VII. Of *Polypi.*

POLYPI are pendulous, fleshy, indolent tumors, so called from their supposed resemblance to the animal of that name. They may be found in different cavities of the body, and originate from the lining membrane; but those which come under surgical treatment are found in the nose, mouth, throat, and outer passage of the ear, and in the vagina and rectum. They are divided into two classes; the one soft and compressible, the other extremely firm. Both of them bleed on being fretted or roughly handled. The soft kind shrivels and contracts in a dry atmosphere, (this is particularly the case with those of the nose); but the firm are not affected by the influence of the weather. Their colour is commonly pale and transparent, and sometimes a deep red.

The pain at the commencement of the disorder is always inconsiderable; but increases in those of a hard nature as they increase in size. Sometimes polypi of this kind become unequal, and form ulcers over the whole surface, discharging fetid matter in considerable quantity. They are apt at this time, unless extirpated, to degenerate into cancer.

Most frequently they arise from local injury, or whatever tends to produce and support an inflamed state of the part. Scrophula and lues venerea, though considered by some authors as frequently giving rise to them, seem only to be exciting causes; for in lues venerea in particular, polypi when present remain after the disease is cured.

The prognosis must depend much upon their situation and their consistence. The soft kind being seldom painful, may be removed at any period with little danger; but the hard kind are generally not only painful, but more apt to degenerate into cancer, or to return after being removed. The soft kind therefore may be removed in general with success; but when polypi of a harder nature exist, the prognosis will be much more unfavourable.

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with respect to the treatment.—As long as they remain stationary, they are not to be touched; but when they continue to grow, we ought to use astringent remedies, especially a strong solution of alum, a decoction of oak bark, vinegar, ardent spirits, &c. The softer kinds of polypi may frequently be prevented for a long time from increasing in size, and sometimes they even become considerably smaller. Mercury has been found rather to make them worse; caustic and other corroding applications have been of use in the softer kind, though they have not produced a cure. Setons have likewise been used with little advantage. It is therefore found necessary to have recourse to a more effectual practice; and with this view the knife, scissars, forceps, or ligature, are more generally recommended. The knife and scissars may be used when the roots of the tumor can be readily come at; but polypi are seldom so situated as to render excision practicable; and even when they are, the hemorrhagy may be attended with considerable danger. The removal of a polypus by tearing or twisting it with the forceps, Plate CCCCLXXXVII. fig. 4. is occasionally practised; but as ligatures are less painful, and fully as effectual, they are now more generally employed. The ligatures consist of wire, catgut, silk cord, &c. Different methods have been employed for passing these over polypi, according to their different situations.

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Method of
applying
a ligature to
them.

When the ligature is to be applied, it is to be passed double over the tumor, and conducted to the root of it by means of the fingers or by slit probes, as in Plate CCCCLXXXVII. fig. 5. or rings, Plate CCCCLXXXVII. fig. 6. as may be best suited to the shape and size of the passage. The ends of the ligature are then to be introduced into a single or double canula, as in Plate CCCCLXXXVII. fig. 7. which is to be pushed along the opposite side of the polypus till the end of the canula reach the root of it, when the ligature is to be drawn somewhat tight, and fastened to the canula which is to be left in the passage. The ligature is to be daily tightened till the tumor drop off. In this manner the largest polypus may be removed equally well with those of a smaller size. Should any part of it remain, it may be destroyed by caustic, and different instruments are contrived for conducting this to the root of the tumor.

What has been said of the treatment of polypi in general, readily applies to those seated in the nose, outer passage of the ear, the rectum, and the vagina. It likewise applies to those in the throat; only that instead of passing the ligature through the mouth, it is to be passed through one of the nostrils. The operator is then to introduce one or two of his fingers into the mouth, and open the doubling of the ligature, which he is to pass over the polypus, and having pressed it down to the root of it, to proceed as before directed.

CHAP. VII. Of Diseases of the Bones.

THE bones, as well as the softer parts, are liable to be swelled, either throughout their whole length, or to have tumors formed on particular parts of them.

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Exostosis.

Exostosis is one species of tumor of the bone. According to Mr Bromfield, no swelling should be called so, but an excrescence continued from a bone, like a branch from the trunk of a tree. Under this head therefore is ranked the *benign node*, which may be produced by external injury, such as contusions and fractures: it can hardly be called a disease, as pain seldom succeeds, but rather a deformity.

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Tophus.

There are risings or tumors observable on the bones which are often the consequences of venereal virus, and are termed *tophi*, *gummi*, or *nodes*.—*Tophus* is a soft tumor in the bone; and seems to be formed of a chalky substance, that is inter-

mediate between the osseous fibres. These eretaceous extravasations are sometimes found on the ligaments and tendons, as well as on the bone; and may sometimes be taken out by the knife. We have many instances where chalk stones in gouty people make their way out through the skin of the fingers and toes.

Gummi is a soft tumor on the surface of the bone, between it and the periosteum; and its contents resemble gum softened, from whence it has taken its name. Possibly, by obstruction in the nutrient vessels of the bone, a rupture of some of them occasions the serous liquor to escape, which, by making its way between the fibres of the bone, arrives at its surface; and being detained by the resistance of the periosteum, its most liquid parts being evaporated, and the remainder condensed by the inflammation, and consequently this inelastic covering being stretched, it becomes inspissated, and forms this species of *exostosis*, as it is generally called. When this is the cause, and the indisposition of the habit in general got the better of, pressure by a steel instrument, adapted to the part affected, is the proper cure.

The confirmed venereal node has the appearance of a divarication of the osseous fibres, probably from some inspissated humour obstructing the nutrient vessels, but not extravasated; this occasioning an extension of the periosteum, produces a violent pain, which, when nocturnal, is the characteristic of a venereal cause. When the periosteum is thickened, but the bone not affected, a course of mercury, by attenuating the obstructed humour, and fitting it to be carried out of the body by the proper outlets, will often produce a perfect cure: but when the bone itself is diseased, this method will fail. But here the division of the extended periosteum has been known to give perfect ease.

The usual method, formerly, was to apply a caustic equal to the extent of the node, which being laid bare, required exfoliation before it could be cicatrized. If the incision is made early, that is, before matter be formed under the investing membrane, it seldom requires exfoliation; and, as we often find that the bone itself is not affected, but only the periosteum thickened, we may be deceived even after a careful examination: it is therefore proper that the patient should be pretty far advanced in a course of mercurial unction before even the incision is made; for, should the tumor decrease, and the pain abate during the course, surgical assistance, with the knife, most likely may become unnecessary.

A bone may become carious first in its internal parts; and that from external injury, as well as from a vitiated state of the animal-fluids. Authors seem not to agree as to the technical term for this kind of disease of the bones; some calling it *cancer* or *gangræna ossis*; others, *spina ventosa*, from the pointed extuberances usually attendant on this disorder of the bone; and some again *teredo*, from the appearance of the carious bone, like wood that is worm-eaten.

It is universally allowed, that this disease takes its rise from matter being formed either in the diploe, or in the marrow: whenever obstruction is begun in the vessels expanded on, or terminating in, the medullary cysts, the consequence will be inflammation, and, if not early removed, matter will form; for this reason this case may be called *abscessus in medulla*. Whenever, then, a patient complains of dull heavy pain, deeply situated in the bone, possibly consequent to a violent blow received on the part some time before, though the integuments appear perfectly sound, and the bone itself not in the least injured, we have great reason to suspect an abscessus in the medulla. Children of a bad habit of body, though they have not suffered any external injury, will often become lame, and complain of the limb being remarkably heavy; and though not attended with acute pain,

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Abscessus in
medulla, or
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of this dis-
ease.

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from cur-
vature of
the spine.122
Of brittle-
ness of the
bones.123
Rickets.

pain, yet the dull throbbing uneasiness is constant. If rigors happen during the time the patient labours under this indisposition, it generally implies that matter will be formed within the substance of the bone. If the extremities of the bone complained of begin, or if it becomes enlarged throughout its whole extent, it may be known to be an abscess in medulla, or true spina ventosa, as it is called: if neither of these symptoms take place, the great insensibility of the bone in some subjects will prevent that acuteness of pain usual in other parts where matter is formed, though the acrid matter is eroding the bone during the whole time it is contained within it. This matter at length having made its way through, arrives at the periosteum, where it creates most violent pain, as well from its sharpness as from its increased quantity, occasioning an extension of the periosteum. The integuments then become swelled and inflamed, and have a sort of emphysematous feel. On being examined by pressure, the tumor will sometimes be lessened, from part of the matter retiring into the bone: from this appearance to the touch, most likely the name of *ventosa* was added to the term *spina*. When we are assured of matter being under the periosteum, we cannot be too early in letting it out, as it will save a considerable deal of pain to the patient, though probably it may not be of any considerable advantage in respect to the carious bone; for, where the fluids in general are vitiated, no chance of cure can be expected from topical remedies; but where the constitution is mended, nature will sometimes astonish us in her part, as the carious bone will be thrown off from the epiphyses, or the teredines will be filled up by the ossific matter that flows from the parts of the bone where some of the spinæ have come away.

If proper medicines are given, the children well supported, and the parts kept clean and dry, patience and perseverance will frequently give great credit to the surgeon. In case it should have been thought advisable to apply a trephine, to give free discharge to the matter, the washing it away, as well as the small crumbings of the carious bone, by means of deterfive and drying injections, has been known to contribute greatly to the curing this kind of caries, after the habit of body in general had been mended.

Besides those above-mentioned, the bones are liable to two opposite diseases; the one termed *friabilitas*, the other *mollities*; the former peculiar to adults, the latter more frequent in infants, though sometimes seen in adults, from a vitiated state of their juices.

The bones, when deprived of their cementing liquor, by passing through fire, become friable. From repeated salivations, and in old people, they have been rendered extremely brittle; inasmuch that in many subjects they have been fractured merely from their weight and the action of the muscles: but in such cases, this is not owing to the friability of the bones, but to the loss of substance, from the erosion of the bone by an acrimonious humour thrown on it; to which cause perhaps may be attributed the disease called *rickets* in children. The effects of scorbutic humour in rendering the bones soft in many instances, have often been remarked.

By proper diet, gentle friction with coarse cloths, exercise, and cold bathing, rickety children will frequently get their constitution so much changed, as that, by the time they arrive at the age of 20 years, there shall not remain the least vestige of their former disease. The epiphyses are generally most affected in this species of the disorder. For want of early attention to invalids of this sort, we find that their bones not only become soft, and yield to the powers of the muscles, but remain distorted the rest of their lives, though they have acquired a perfect degree of solidi-

ty. In such cases, correcting the vitiated juices only will not restore the bones to their natural state; therefore the assistance of a skilful mechanic is necessary both to support the parts improperly acted on, and to alter the line of direction of the distorted osseous fibres.

Though the curvature of the extremities, or thickness of the ends of the bones near their articulations, may give the first alarm to those who are constantly with children, yet there are other symptoms that give earlier notice than these; and had they been timely discovered by proper judges, it is highly probable that the curvature of the limbs in many children might not have happened. The belly generally becomes larger in this disease, from the increased size of the contained bowels, as it is not unlikely but that the mesenteric glands are the first parts obstructed; obstructions of the liver, spleen, and pancreas, soon follow; the head then becomes enlarged; then a difficulty of breathing, which is generally supposed to be the effects of taking cold, succeeds; the sternum is elevated and sharp, and the thorax becomes contracted; the spine is protruded in several parts; the pelvis altered, according to the pressure of the parts within, and habitual inclination of the patient, at times, to obtain that line of direction in which the perpendicular from the centre of gravity may fall within the common base of the body, the extremities of the cylindrical bones, and the ends of the ribs next the sternum, become enlarged; soon after this the bones in general become soft and flexible, yielding in such directions as the strongest muscles determine by their actions.

The bones of children who die of this disorder, we observe, are not only rendered soft, but the vessels within their substance are replete with blood of a texture totally broken, and having more the appearance of thin chocolate than blood: the periosteum in many places is separated, and the intermediate space between it and the bone filled with extravasated fluid; and caries is almost as frequent as the separation of the periosteum. The muscles in such bodies generally appear pale and flabby.

Where the affection of the mesenteric glands is evident, Mr Bromfield asserts, that after a dose or two of the pulvis basilicus to empty the intestines thoroughly, the purified crude quicksilver is by much the most efficacious medicine to remove obstructions in those glands. When the belly begins to soften and subside, the chyle passes without interruption, and the child begins to get flesh; then the cold bath becomes truly serviceable, and the decoction or cold infusion of the Peruvian bark is a proper restorative; but the cold bath used too early, or the bark given before there is a free circulation of chyle through the lacteals, would be very injurious.

The mollities ossium, in some cases, may be produced from a redundancy of the oleaginous parts of the blood, or from a laxity of the solids, by which the fluids are not sufficiently attenuated, nor properly blended and mixed: the consequence of which will be obstructed perspiration, the habit in general loaded with gross, phlegmatic, and serous humours, and the ossific matter not united or condensed as in an healthy state. The method of cure confirms us in the cause of these symptoms; for, by strengthening the fibrous system, by using gentle exercise, a dry diet, good air, aromatics, and cold bathing, this kind of invalids are generally restored to health.

Among the diseases of the bones we may likewise take notice of that *palsy of the lower extremities* which takes place, as is generally supposed, in consequence of a curvature in some part of the spine. To this distemper both sexes and all ages are equally liable. When it attacks an infant of only a year or two old or under, the true cause of it is sel-

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the Bones.

dom discovered until some time after the effect has taken place. The child is said to be uncommonly backward in the use of his legs, or it is thought to have received some hurt in the birth. When the child is of an age sufficient to have already walked, and who has been able to walk, the loss of the use of his legs is gradual, though in general not very slow. He at first complains of being very soon tired, is languid, listless, and unwilling to move much or at all briskly. Soon after this he may be observed frequently to trip and stumble, though there be no impediment in his way; and whenever he attempts to move briskly, he finds that his legs involuntarily cross each other, by which he is frequently thrown down without stumbling; and when he endeavours to stand still in an erect posture without support, even for a few minutes, his knees give way and bend forward. As the distemper advances, it will be found that he cannot, without much difficulty and deliberation, direct either of his feet exactly to any one point; and very soon after this, both legs and thighs lose a good deal of their natural sensibility, and become quite useless. In adults, the progress of the disease is much quicker, but the symptoms nearly the same.

Until the curvature of the spine is discovered, the complaint generally passes for a nervous one; but when the state of the back-bone is adverted to, recourse is almost always had to some previous violence to account for it. That this might have been the case in some few instances might be admitted; but in by far the greatest number some predisposing cause must be looked for.

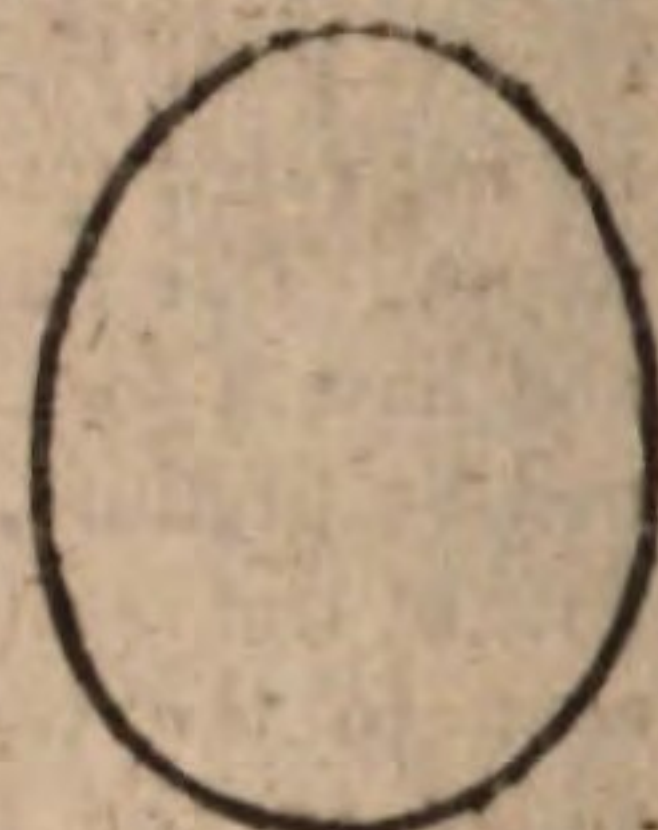
Mr Pott, who has written a treatise upon this disease, recommends it to our observation, that though the lower limbs are rendered almost useless, or even entirely so, yet there are some circumstances in which it differs from a common nervous palsy. The legs and thighs, though so much affected, have neither the flabby feel of a truly paralytic limb; nor have they that seeming looseness at the joints, nor the total incapacity of resistance which allows the latter to be twisted almost in all directions: on the contrary, the joints have frequently a considerable degree of stiffness, particularly the ankles; by which stiffness the feet of children are generally pointed downward, and they are prevented from setting them flat upon the ground.

At first the general health of the patient seems not to be at all, or at least not materially affected; but when the disease has continued for some time, and the curvature is thereby increased, many inconveniences and complaints come on; such as difficulty in respiration, indigestion, pain, and what they call *tightness at the stomach*, obstinate constipations, purgings, involuntary flux of urine and feces, &c. with the addition of some nervous complaints, which are partly caused by the alterations made in the form of the cavity of the thorax, and partly by impressions made on the abdominal viscera.

Mr Pott was led to a knowledge of the true cause and cure of this distemper, from observing the case of a youth of 14, who was restored to the use of his limbs immediately after a seemingly accidental abscess near the part. From this he was inclined to think, that the curvature of the spine was not the original cause of the disorder, but that the surrounding parts were predisposed towards it by some affection of the solids and fluids there; and he was confirmed in these suspicions by a variety of appearances, which he observed both in the living body and upon dissection of the subject after death; all of which are narrated at full length in his treatise upon this subject.

"The remedy (says he) for this most dreadful disease consists merely in procuring a large discharge of matter, by suppuration, from underneath the membrana adiposa on each

side of the curvature, and in maintaining such discharge until the patient shall have perfectly recovered the use of his legs. To accomplish this purpose, I have made use of different means, such as setons, issues made by incision, and issues made by caustic; and although there be no very material difference, I do upon the whole prefer the last. A seton is a painful and a nasty thing: besides which it frequently wears through the skin before the end for which it was made can be accomplished. Issues made by incision, if they be large enough for the intended purpose, are apt to become inflamed, and to be very troublesome before they come to suppuration; but openings made by caustic are not in general liable to any of these inconveniences, at least not so frequently nor in the same degree: they are neither so troublesome to make or maintain. I make the eschars about this size and shape on each side the curve, taking care to leave a sufficient portion of skin between them. In a few days, when the eschar begins to loosen and separate, I cut out all the middle, and put into each a large kidney-bean: when the bottoms of the sores are become clean by suppuration, I sprinkle, every third or fourth day, a small quantity of finely powdered cantharides on them, by which the sores are prevented from contracting, the discharge increased, and possibly other benefit obtained. The issues I keep open until the cure is complete; that is, until the patient recovers perfectly the use of his legs, or even for some time longer: and I should think that it would be more prudent to heal only one of them first, keeping the other open for some time; that is, not only until the patient can walk, but until he can walk firmly, briskly, and without the assistance of a stick: until he can stand quite upright, and has recovered all the height which the habit or rather the necessity of stooping, occasioned by the distemper, had made him lose."

Blood-
letting.

CHAP. VIII. Of Blood-letting.

SECT. I. Of Blood-letting in general.

BLOOD-LETTING is performed either to lessen the quantity of circulating fluid, or to relieve a particular part: hence we have the terms of *general* and *local* blood-letting.

General blood-letting is either performed upon a vein or an artery; and from this circumstance arise the appellation of *phlebotomy* and *arteriotomy*.

Local or topical blood-letting is performed by scarificators and cupping-glasses, by leeches, or by punctures made with a lancet, as may be most suitable to the nature of the disease it is intended to remedy.

There are some general rules and observations which relate equally to this operation in whatever part of the body it is practised: these we shall in the first place enumerate, and shall afterwards proceed to treat particularly of blood-letting in the arm and other parts.

I. In this, as in every other operation, the situation of the patient, and of the operator likewise, ought to be precisely fixed. The situation of a patient, during the operation of blood-letting, has a considerable influence on the effects produced, and therefore merits particular attention. In some disorders, it is the object of this remedy to evacuate a considerable quantity of blood without inducing fainting: When this is the case, and when from former experience it is known that the patient is liable during the evacuation to fall into a faintish state, a horizontal posture ought to be preferred to every other; for fainting is not near so ready to occur in a horizontal as in an erect posture. It now and then happens, however,

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however, that one material advantage expected from the operation of blood-letting, is the production of a state of deliquium; as, for instance, in cases of strangulated hernia, where a general relaxation of the system is sometimes desirable. In all such circumstances, instead of a horizontal posture, the more erect the patient is kept, the more readily will a state of fainting be induced. The patient ought to be so placed, that the principal light of the apartment shall fall directly upon the part to be operated upon, that the vein to be opened may be made as apparent as possible.

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Method of
compress-
sing the
vein.

II. The patient being properly seated, the next step is, by means of a proper bandage of silk, linen, or woollen cloth, which has more elasticity, so to compress the vein intended to be opened, as to prevent the blood from returning to the heart. An equal degree of pressure ought to be applied to all the other veins of the part: for if this be not attended to, the communication preserved by the collateral corresponding branches would render the pressure upon any one particular vein of very little importance. This pressure upon the veins, by inducing an accumulation of their contents, tends to bring them more evidently into view, and consequently renders it easier for the operator to effect a proper opening than he would otherwise find it. The pressure, however, ought never to be carried so far as to obstruct the circulation in the corresponding arteries, otherwise no discharge of blood can take place. When we see that it has the effect of raising the veins, while at the same time the pulsation of the artery is distinctly felt in that part of the member which lies on the side of the ligature most distant from the heart, we may be certain that it is to a very proper degree, and that it ought not to be carried farther; for by the swelling of the veins we are sure that they are sufficiently compressed; and by the arteries continuing to beat, it is evident that a continued flow of blood may be expected.

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Instrument
to be used.

III. The reflux of blood to the heart being in this manner prevented, the next question to be determined is, the best method of making an opening into the vein. Different instruments have been invented for this purpose; but there are two only which have been retained in use, and which are all therefore that here require to be mentioned. These are the lancet and the phlegm. This last, on being placed immediately on the part to be cut, is, by means of a spring, pushed suddenly into the vein, and produces an opening of the exact size of the instrument employed.

When it is determined to employ the lancet, which is by far the safest, the form of that instrument is next the object of attention. The broad-shouldered lancet ought to be laid entirely aside; because the broadness of its shoulders produces always a wound in the external teguments of perhaps three times the size of the opening made in the vein; a circumstance which adds no advantage whatever to the operation; on the contrary, it produces much unnecessary pain; renders it frequently a very difficult matter to command a stoppage of the blood; and the wounds produced by it are commonly so extensive as to be liable to terminate in partial suppurations.

The spear-pointed lancet, on the contrary, represented in Plate CCCCLXXXVII. fig. 8. is in every respect well calculated for the purpose of venesection. From the acuteness of its point, it enters the teguments and vein with very little pain; which is with many patients a circumstance of no small importance. We are sure of making the opening in the vein equal, or nearly so, to the orifice in the external teguments; and the discharge of blood produced by an opening made with one of these lancets, is commonly put a stop to with great ease immediately on removing the ligature upon the vein.

IV. The form of lancet being thus fixed upon, we come

now to speak of the method of using it. The surgeon and patient being both properly seated, and the ligature having been applied for a short space of time in order to produce some degree of swelling in the veins, that vein is to be made choice of which, at the same time that it appears conspicuously enough, is found to roll less than the others on being pressed upon by the fingers. It is scarcely thought necessary to observe here, that when a vein appears to be so immediately connected with a contiguous artery or tendon, as evidently to produce some risk of wounding these parts in the operation, another vein not liable to such hazard, if it can be procured, ought undoubtedly to be preferred. Veins may lie directly above both arteries and tendons, and yet no manner of risk be incurred by opening them, provided the operator is sufficiently steady and attentive; but it does now and then happen, that veins are so nearly and intimately connected with these parts, as to render it hazardous even for the most dexterous surgeon to attempt this operation.

The vein being at last made choice of, the surgeon, if he is to use his right-hand in the operation, takes a firm hold of the member from whence the blood is to be drawn with his left, and with the thumb of the same hand he is now to make such a degree of pressure upon the vein, about an inch and a half below the part where the orifice is to be made, as not only to render the skin and teguments somewhat tense; but at the same time to interrupt for a little all communication between the under part of the vein and that portion of it lying between the ligature and the thumb placed as thus directed.

The lancet being drawn out so as to form nearly a right angle with the scales, the operator now takes it between the finger and thumb of his right-hand; and leaving at least one half of the blade uncovered, he rests his hand on the middle-finger, ring-finger, and little-finger, all placed as conveniently as possible in the neighbourhood of the vein from whence the blood is to be taken; and having pushed the point of the instrument freely through the skin and teguments into the vein, he now carries it forward in an oblique direction, till the orifice is of the size he inclines to have it; taking care, during the time of pushing on the lancet, that its point be kept in as straight a direction as possible, for fear of dipping into the parts below.

The instrument is now to be withdrawn; and the surgeon, removing the thumb of his left hand, is to allow the vein to empty itself freely into the different cups previously provided for the purpose.

It is of importance to observe, that during the time the blood is discharging, the member ought to be kept in exactly the same posture it was in when the lancet was first introduced: otherwise the orifice in the skin is apt to slip over the opening in the vein; a circumstance which always proves inconvenient, and on some occasions produces a good deal of trouble by the blood from the vein insinuating itself into the surrounding cellular substance.

V. When the vein is properly cut, and the orifice is made sufficiently large, it rarely occurs that any difficulty is experienced in procuring all the blood that is wanted. But when this last circumstance occurs, from the patient becoming faintish, a stream of fresh air ought to be admitted to the apartment, wine or some other cordial should be administered, and the patient ought to be laid in a horizontal posture. By these means the faintishness will in general be soon removed: but if still the blood should not flow freely, the member ought to be put into all the variety of positions that can probably assist in bringing the openings of the skin and other teguments to correspond with that of the vein; which will soon be known to have happened by the blood

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blood.

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blood beginning instantly to flow. Throwing the muscles of the part into constant action, by giving the patient a cane or any other firm substance to turn frequently round in his hand when the operation is done in the arm, will often answer in producing a constant flow of blood from a vein when every other means has failed: And, lastly, when the pulse in the inferior part of the member is felt very feeble, or especially if it cannot be distinguished at all, we may be thereby rendered certain that the ligature is too tight, and may in general have it in our power to produce an immediate flow of blood, by removing the compression thus improperly made upon the arteries of the part.

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Method of stopping too great a flux.

VI. A quantity of blood proportioned to the nature of the disorder being thus discharged, the pressure upon the superior part of the vein should be immediately removed; and this being done, if the spear-pointed lancet has been used, all farther loss of blood will in general stop immediately. The contrary of this, however, sometimes occurs, and blood continues to flow freely even after the ligature is removed. When this is the case, the operator ought to compress the vein both above and below the orifice, by means of the finger and thumb of one hand, so as to prevent any farther loss of blood. This being done, and the orifice being cleared of every particle of blood, the sides of it should be laid as exactly together as possible; and a piece of court or any other adhesive plaster being so applied as to retain them, it will seldom happen that any kind of bandage is necessary: but when the blood has issued with uncommon violence during the operation, and has been difficult to command after the removal of the ligature, in such instances it will be prudent to apply a small compress of linen over the plaster, and to secure the whole with a linen roller properly applied round the member.

SECT. II. Of Venesection in different Parts of the Body.

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Venesection in the arm.

WHEN venesection is to be performed in the arm, the ligature for stopping the circulation ought to be placed about an inch or an inch and a half above the joint of the elbow, and brought twice round: in order to prevent the ends of it from interfering with the lancet, the knot should be made on the outside of the arm. In general, one knot might answer; but a slip-knot being made above the first, renders it more secure, and it is very easily done.

In forming the choice of a vein from whence blood is to be taken, the general rules we have already laid down upon this point must be here particularly attended to. In general the artery lies so low in this place, that the median basilic vein, under which it commonly runs, may be opened with perfect safety; and as this vein in general appears more conspicuous than any of the others, probably from the continued pulsation of the artery below obstructing in some measure the passage of its contents, it is in this respect therefore more properly calculated for this operation than any of the others. Other circumstances occur too which render the median basilic preferable to the cephalic or median cephalic veins for the operation of blood-letting. The former, viz. the median basilic, is less deeply covered with cellular substance; and by lying towards the inner part of the arm, it is more thinly covered with the tendinous expansion of the biceps muscle than either of the others. From these circumstances, the operation is always attended with less pain when done in this vein than in any of the others.

In very corpulent people, it sometimes happens that all the larger veins lie so deep as not to be discovered by the eye; but when they are sensibly felt by the fingers, even although they cannot be seen, they may be always opened with freedom. In a few instances, however, they can neither be distinguished by the eye nor by the finger: in such a si-

tuation, as they may in general be met with about the wrist or on the back-part of the hand, the ligature should be removed from the upper part of the arm; and being applied about half way between the elbow and wrist, the veins below will thereby be brought into view; and wherever a vein can be evidently observed, there can be no danger in having recourse to the operation.

There is only one vein of the neck, viz. the posterior external jugular, which can easily be brought so much into view as to be with propriety opened; and even this lies deeply covered with parts, not only with the skin and cellular substance, but with the fibres of the platysma myoides muscle; so that a considerable degree of pressure becomes necessary in order to raise it to any height. With a view to produce this, the operator's thumb is commonly advised to be placed upon the vein, so as to compress it effectually about an inch or an inch and a half below where the opening is to be made. This, however, seldom proves sufficient for the purpose, as the blood, on being stopped in its progress through this branch, easily finds a passage to the other veins; so that unless the principal vein on the other side of the neck is also compressed, the vein to be opened can never be fully distended. In order to effect this, a firm compress of linen should be applied on the largest vein on the opposite side of the neck; and an ordinary garter, or any other proper ligature, being laid directly over it, should be tied with a firm knot below the opposite arm-pit; taking care to make such a degree of pressure, as to put an entire stop to the circulation in the vein, which in this way may be easily effected without producing any obstruction to the patient's breathing. But to prevent every inconvenience of this kind, see an instrument contrived for the purpose, Plate CCCCLXXXVII. fig. 9.

This being done, and the patient's head properly supported, the operator, with the thumb of his left hand, is now to make a sufficient pressure upon the vein to be opened; and with the lancet in his right hand is to penetrate at once into the vein; and before withdrawing the instrument, an orifice should be made large enough for the intended evacuation. It may be proper to observe, that a more extensive opening ought always to be made here than is necessary in the arm, otherwise the quantity of blood is generally procured with difficulty: and besides, there is not the same necessity for caution on this point here that there is in the arm; for it seldom or never happens that any difficulty occurs in this situation, in putting a stop to the blood after the pressure is removed from the veins; all that is commonly necessary for this purpose being a slip of adhesive plaster without any bandage whatever.

In order to bring the vein more clearly into view, so as afterwards to be able to open it with more exactness, it has been recommended, that the skin, cellular substance, and muscular fibres covering the vein, should be previously divided with a scalpel before attempting to push the lancet into it. There is not, however, any necessity for this precaution, as it rarely happens that any difficulty is experienced in procuring a free discharge of blood by opening the vein and teguments at once in the manner directed. And it is here, as in every instance where it is necessary to take blood by a lancet, if it is not done at once, the patient is much disappointed, and is sure to attribute the failure entirely to a fault in the operator.

When blood is to be discharged from the veins of the ankle or feet, the ligature being applied a little above the ankle-joint, all the branches of the vena saphena, both in the inside and outside of the foot, come at once into view; and as this vein lies everywhere very superficial, being in general covered with skin only, wherever a proper

Venesection in different Parts of the Body.

137
Venesection in the neck.

138
Venesection in the ankles and feet.

Venefec-
tion in dif-
ferent Parts
of the Bo-
dy.

per vein appears conspicuously it may with safety be open-
ed.

With a view to encourage the discharge of blood, it has been a constant practice in blood-letting, in these veins, to dip the feet into warm water immediately on the orifice being made. But this is a very inaccurate method of proceeding, as the quantity of blood taken in this manner can never be ascertained with precision; for the blood being all mixed with the water, the operator can never be in any degree certain as to this point: and besides, there does not appear to be any necessity for this assistance; for when the compression of the superior part of the veins is made effectual, and the orifice is of a proper size, there is seldom more difficulty in obtaining a full discharge of blood from the veins of these parts than from any other veins of the body.

On removing the ligature, the discharge is generally stopped at once; so that a piece of adhesive plaster applied over the orifice answers all the purpose of a bandage. The arm, neck, and ankles are the parts from whence blood is usually taken by venesection; but on some occasions, where the contiguous parts have been particularly affected, it has been thought advisable to perform venesection in other places.

139
Venefec-
tion under
the tongue.

When venesection is to be performed in the veins called *ranula* under the tongue, the apex of the tongue is to be elevated, and the vein on each side opened, because the opening of one only will hardly ever discharge blood enough. After a sufficient quantity has been discharged, some cold astringent fluid taken into the mouth will generally stop the hemorrhagy.

140
Venefec-
tion in the
penis.

The vena dorsalis penis, which runs along the back or upper side of this member, being generally pretty much distended, and conspicuous in an inflammation of this part, may be opened about the middle or back part of the penis; and a sufficient quantity of blood be discharged proportionable to the urgency of the symptoms. This being done, apply a compress and bandage proper for the penis. The arteries and nerves which lie on each side of the vein are to be avoided: nor ought the bandage to be too tight, otherwise the inflammation and other symptoms may turn out worse than before.

When it is found necessary to discharge blood in this manner from the penis, the veins can be easily brought into view, by producing an accumulation of their contents in the same manner as in other parts of the body, through the intervention of a ligature: but in the tongue, in the hæmorrhoidal veins about the anus, and other parts where compression cannot be applied, all that the surgeon can do, is to make an orifice of a proper size in that part of the vein which shows itself most evidently; and if a sufficient discharge of blood is not thus produced, as there is no other method of effecting it, immersing the parts in warm water may in such circumstances be a very necessary measure.

141
Venefec-
tion in the
eye.

There are several ways of performing the operation of blood-letting in the eyes. We shall here only relate the chief: First, the patient is to be seated conveniently on the bed-side or on a chair, with his head held in a proper posture by an assistant; which done, the surgeon makes a transverse incision with a lancet upon the turgid small vessels in the corners of the eye, so as to open them or cut them quite across. Some use a small pair of scissors, instead of a lancet, to divide the vessels; but in using either of them, the eye-lids must be separated from each other by the fingers of one hand, while the vessels are cut by instruments held in the other. Some, again, elevate the small turgid vessels with a crooked needle before they divide them, the eye-lids being in the mean time held asunder by an assistant. The small vessels being thus opened or divided, their discharge of blood should be

promoted by fomentations of warm water frequently applied to the eye by means of a sponge or soft linen rags.

Among other methods that have been proposed for scarifying the blood-vessels of the eye, the beads of rough barley were at one period much extolled, and are still employed by some individuals. By drawing them over the surface of the eye, in a direction contrary to the sharp spiculae with which they are furnished, a considerable discharge of blood is thereby produced: But the pain attending this operation is exquisite; and as it does not possess any superior advantage to the method with the lancet, it is now falling into general disuse.

SECT. III. Of Arteriotomy.

WHATEVER particular advantages may in theory have been expected from arteriotomy, and however some of its supporters may have recommended it, not only as being in many instances preferable to venesection, but as an operation perfectly safe even in vessels of considerable size; yet the most strenuous friends to the practice have shrunk from any real attempt of this kind on the larger arteries. In-
stances have no doubt occurred of large arteries having been opened without any danger ensuing; but these are so exceedingly rare, that no practitioner of experience will, from that consideration, be induced coolly to proceed to open any artery of importance. The smaller branches of arteries may indeed be opened with great safety, when they are not deeply covered, and especially when they lie contiguous to bones; but in any of the larger arteries, the attempt must be always attended with so much hazard, and the advantages to be expected from it, in preference to venesection, are apparently so trifling, as must in all probability prevent it from ever being carried into execution.

There are very few arteries, therefore, which, with any propriety, can be opened: the different branches of the temporal are the only arteries indeed from whence blood, in ordinary practice, is ever taken; for although the opening of some other branches of arteries has by some been proposed, yet they are situated in such a manner that they either cannot be readily come at, or being in the neighbourhood of so large nerves, the opening of them might be attended with bad consequences. In performing this operation on any of the temporal branches, if the artery lies superficial, it may be done with one push of the lancet, in the same manner as was directed for venesection; but when the artery lies deeply covered with cellular substance, it is always necessary to lay it fairly open to view, before making the orifice with the lancet: for in all the smaller arteries, when they are cut entirely across, there is little chance of being able to procure any considerable quantity of blood from them; as, when divided in this manner, they are sure to retract considerably within the surrounding parts, which commonly puts a stop to all farther evacuation.

Some degree of nicety is also necessary in making the opening into the artery of a proper oblique direction, neither quite across nor directly longitudinal; for a longitudinal opening never bleeds so freely, either in an artery or in a vein, as when its direction is somewhat oblique.

If the opening has been properly made, and if the artery is of any tolerable size, it will at once discharge very freely without any compression; but when the evacuation does not go on so well as could be wished, the discharge may be always assisted by compressing the artery immediately above the orifice, between it and the corresponding veins. The quantity of blood being thus discharged, it will commonly happen, that a very slight compression on these smaller arteries will suffice for putting a stop to the evacuation: and
8
whatever

Arteriotomy.

142
Arteriotomy seldom practised.

143
Arteries usually opened.

144
Method of performing the operation.

Topical
Bleeding.

whatever pressure is found necessary, may be here applied in the same manner as was directed in venesection.

It happens, however, in some instances, that this does not succeed, the orifice continuing to burst out from time to time, so as to be productive of much distress and inconvenience.

145
Method of
stopping
the blood.

In this situation there are three different methods by which we may with tolerable certainty put a stop to the farther discharge of blood. 1st, If the artery is small, as all the branches of the temporal arteries commonly are, the cutting it entirely across, exactly at the orifice made with the lancet, by allowing it to retract within the surrounding parts, generally puts an immediate stop to the discharge. 2d, When that is not consented to, we have it always in our power to secure the bleeding vessel with a ligature, as we would do an artery accidentally divided in any part of the body. And, lastly, if neither of these methods is agreed to by the patient, we can, by means of a constant regular pressure, obliterate the cavity of the artery at the place where the operation has been performed, by producing the accretion of its sides. Different bandages have been contrived for compressing the temporal artery; but none of them answer the purpose so easily and so effectually as the one figured in Plate CCCCLXXXVII. fig. 10. This method is more tedious; but to timid patients it generally proves more acceptable than either of the other two.

SECT. IV. Of Topical Bleeding.

WHEN, either from the severity of a local fixed pain, or from any other cause, it is wished to evacuate blood directly from the small vessels of the part affected, instead of opening any of the larger arteries or veins, the following are the different modes proposed for effecting it, viz. by means of leeches; by slight scarifications with the shoulder or edge of a lancet; and, lastly, by means of an instrument termed a *scarificator*, (Plate CCCCLXXXVII. fig. 11.); in which sixteen or twenty lancets are commonly placed, in such a manner, that, when the instrument is applied to the part affected, the whole number of lancets contained in it are, by means of a strong spring, pushed suddenly into it, to the depth at which the instrument has been previously regulated. This being done, as the smaller blood-vessels only by this operation are ever intended to be cut, and as these do not commonly discharge freely, some means or other become necessary for promoting the evacuation.

146
Method of
bleeding
with the
scarificator

Various methods have been proposed for this purpose. Glasses fitted to the form of the affected parts, with a small hole in the bottom of each, were long ago contrived; and these being placed upon the scarified parts, a degree of suction was produced by a person's mouth sufficient for nearly exhausting the air contained in the glass: and this accordingly was a sure enough method of increasing the evacuation of blood to a certain extent. But as this was attended with a good deal of trouble, and besides did not on every occasion prove altogether effectual, an exhausting syringe was at last adapted to the glass: which did indeed answer as a very certain method of extracting the air contained in it; but the application of this instrument for any length of time is very troublesome, and it is difficult to preserve the syringe always air-tight.

147
And cup-
ping-glass.

The application of heat to the *cupping-glasses*, represented in Plate CCCCLXXXVII. fig. 12. has been found to rarefy the air contained in them to a degree sufficient for producing a very considerable suction. And as the instrument in this simple form answers the purpose in view with very little trouble to the operator, and as it is at all times easily obtained, the use of the syringe has therefore been laid aside.

There are different methods adopted for thus applying heat to the cavity of the glass. By supporting the mouth of it for a few seconds above the flame of a taper, the air may be sufficiently rarefied; but if the flame is not kept exactly in the middle, but is allowed to touch either the sides or bottom of the glass, it is very apt to make it crack. A more certain, as well as an easier, method of applying the heat, is to dip a piece of soft bibulous paper in spirit of wine; and having set it on fire, to put it into the bottom of the glass, and, on its being nearly extinguished, to apply the mouth of the instrument directly upon the scarified part. This degree of heat, which may be always regulated by the size of the piece of paper, and which it is evident ought to be always in proportion to the size of the glass, if long enough applied, proves always sufficient for rarefying the air very effectually, and at the same time, if done with any manner of caution, never injures the glass in the least.

Topical
Bleeding.

The glass having been thus applied, if the scarifications have been properly made, they instantly begin to discharge freely: and so soon as the instrument is nearly full of blood, it should be taken away; which may be always easily done by raising one side of it, so as to give access to the external air. When more blood is wished to be taken, the parts should be bathed with warm water; and being made perfectly dry, another glass, exactly the size of the former, should be instantly applied in the very same manner: and thus, if the scarificator has been made to push to a sufficient depth, so as to have cut all the cutaneous vessels of the part, almost any necessary quantity of blood may be obtained. It sometimes happens, however, that the full quantity intended to be discharged cannot be got at one place. In such a case, the scarificator must be again applied on a part as contiguous to the other as possible; and this being done, the application of the glasses must also be renewed as before.

When it is wished to discharge the quantity of blood as quickly as possible, two or more glasses may be applied at once on contiguous parts previously scarified; and, on some occasions, the quantity of blood is more quickly obtained by the cupping-glasses being applied for a few seconds upon the parts to be afterwards scarified. The suction produced by the glasses may possibly have some influence in bringing the more deep-seated vessels into nearer contact with the skin, so that more of them will be cut by the scarificator.

A sufficient quantity of blood being procured, the wounds made by the different lancets should be all perfectly cleared of blood; and a bit of soft linen or charpie, dipped in a little milk or cream, applied over the whole, is the only dressing that is necessary. When dry linen is applied, it not only creates more uneasiness to the patient, but renders the wounds more apt to fester than when it has been previously wetted in the manner directed.

Dry cupping consists in the application of the cupping-glasses directly to the parts affected, without the use of the scarificator. By this means a tumor is produced upon the part; and where any advantage is to be expected from a determination of blood to a particular spot, it may probably be more easily accomplished by this means than by any other.

When the part from which it is intended to produce a local evacuation of this kind is so situated, that a scarificator and cupping-glasses can be applied, this method is greatly preferable to every other; but in inflammatory affections of the eye, of the nose, and of other parts of the face, &c. the scarificator cannot be properly applied directly to the parts affected. In such instances, leeches are commonly

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Dry cup-
ping.

149

Applica-
tion of
had leeches.

¹⁵⁰ Issues, had recourse to, as they can be placed upon almost any spot from whence we would wish to discharge blood.

In the application of these animals, the most effectual method of making them fix upon a particular spot, is to confine them to the part by means of a small wine-glass. Allowing them to creep upon a dry cloth, or upon a dry board, for a few minutes before application, makes them fix more readily; and moistening and cooling the parts on which they are intended to fix, either with milk, cream, or blood, tends also to cause them adhere much more speedily than they otherwise would do. So soon as the leeches have separated, the ordinary method of promoting the discharge of blood, is to cover the parts with linen cloths wet in warm water. In some situations, this may probably be as effectual a method as any other; but wherever the cupping-glasses can be applied over the wounds, they answer the purpose much more effectually.

CHAP. IX. Of Issues.

ISSUES are a kind of artificial ulcers formed in different parts of the body with a view to procure a discharge of purulent matter, which is frequently of advantage in different disorders.

¹⁵⁰ Use of issues. Practitioners were formerly of opinion that issues served as drains to carry off the noxious humours from the blood, and therefore they placed them as near the affected part as possible. But as it is now known that they prove useful merely by the quantity of matter which they afford, they are generally placed where they will occasion the least inconvenience. The most proper parts for them are, the nape of the neck; the middle, outer, and fore part of the humerus; the hollow above the inner side of the knee; or either side of the spine of the back; or between two of the ribs; or wherever there is a sufficiency of cellular substance for the protection of the parts beneath: they ought never to be placed over the belly of a muscle; nor over a tendon, or thinly covered bone; nor near any large blood-vessel.

The issues commonly used are, the blister-issue, the pea-issue, and the seton or cord.

¹⁵¹ The blister-issue. When a blister-issue is to be used, after the blister is removed, a discharge of matter may be kept up by dressing the part daily with an ointment mixed with the powder of cantharides. If the discharge be too little, more of the powder may be used; if too great, or if the part be much inflamed, the issue ointment may be laid aside, and the part dressed with basilicon, or with Turner's cerate, till the discharge be diminished and the inflammation abated. It is most proper sometimes to use the issue ointment and a mild one alternately.

¹⁵² The pea-issue. A pea-issue is formed either by making an incision with a lancet, or by caustic, large enough to admit one or more peas; though sometimes instead of peas, kidney-beans, Gentian root, or orange-peas, are used. When the opening is made by an incision, the skin should be pinched up and cut through, of a size sufficient to receive the substance to be put into it. But when it is to be done by caustic, the common caustic or lapis infernalis of the shops answers best: it ought to be reduced to a paste with a little water or soft soap, to prevent it from spreading; and adhesive plaster, with a small hole cut in the centre of it, should be previously placed, and the caustic paste spread upon the hole in the centre. Over the whole an adhesive plaster should be placed to prevent any caustic from escaping. In ten or twelve hours, the whole may be removed, and in three or four days the eschar will separate, when the opening may be filled with peas, or any of the other substances already mentioned.

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The seton is used where a large quantity of matter is wanted, and especially where it is wished for from deep seated parts. It is frequently used in the back of the neck for diseases of the head or eyes, or between two of the ribs in affections of the breast.

When the cord, which is to be made of threads of cotton or silk, is to be introduced, the parts at which it is to enter and pass out should be previously marked with ink, and a small part of the cord being besmeared with some mild ointment, and passed through the eye of the seton-needle, Plate CCCCLXXXVII. fig. 13. the part is to be supported by an assistant, and the needle passed fairly through, leaving a few inches of the cord hanging out. The needle is now to be removed and the part dressed. By this method matter is produced in quantity proportioned to the degree of irritation applied; and this can be increased or diminished by covering the cord daily before it is drawn with an irritating or mild ointment.

CHAP. X. Of Sutures and Ligatures of Arteries.

SECT. I. Of Sutures.

THE intention of sutures is to unite parts which have been divided, and where the retraction of the lips of the wound has been considerable. The sutures in ordinary use at present, among surgeons, are the interrupted, the quilted, and the twisted. Besides these sutures, adhesive plasters are used for uniting the lips of wounds, which have been termed the *false* or *dry* suture, in opposition to the others which have obtained the name of *true* or *bloody*. The true suture is used in cases of deep wounds, while the false is employed in those of a superficial nature.

¹⁵⁴ Of the interrupted suture. The interrupted suture is made as follows. The wound being emptied of the grumous blood, and the assistant taking care that the lips of it lie quite even, the surgeon is carefully to carry the needles from the bottom outwards; using the caution of making them come out far enough from the edge of the wound, which will not only facilitate the passing the ligature, but will also prevent it from cutting through the skin and flesh; as many more stitches as may be required will be only repetitions of the same process. The threads being all passed, let those be first tied which are in the middle of the wound: though, if the lips are held carefully together all the while, as they should be, it will be of no great consequence which is done first. The most useful kind of knot is a single one first, and then a slip-knot, which may be loosened upon any considerable inflammation taking place. If a violent inflammation should succeed, loosening the ligature only will not suffice; it must be cut through and drawn away, and the wound be treated afterwards without any suture. When the wound is small, the less it is disturbed by dressing the better; but in large ones, there will sometimes be a considerable discharge; and if the threads be not cautiously carried through the bottom of it, abscesses will frequently ensue from the matter being pent up underneath, and not finding issue. If no accident happen, after the lips are firmly agglutinated, the ligatures are to be removed, and the orifices which they leave dressed.

It will readily be understood, that the strength of the ligature and size of the needle ought always to be proportionable to the depth of the sore and retraction of the parts. The proper form of needles is represented in Pl. CCCCLXXXVII. fig. 14.

It must likewise be remembered, that during the cure the suture must be always assisted by the application of bandage, if possible, which is frequently of the greatest importance; and that sort of bandage with two heads, and a slit in the middle,

Sutures.

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Of the
quilled
suture.

middle, which is by much the best, will in most cases be found practicable.

In deep wounds, attended with much retraction, it is always a necessary precaution, to assist the operation of the ligatures by means of bandages, so applied as to afford as much support as possible to the divided parts: But even with every assistance of this nature, it now and then happens, that the divided parts cannot be kept together, retraction occurs to a greater or lesser degree, and the ligatures of course cut asunder the soft parts they were at first made to surround.

With a view to prevent this receding of the teguments and other parts, it was long ago proposed to add to the interrupted suture what was supposed would afford an additional support, viz. quills, or pieces of plaster rolled up into the form of quills; one of which being placed on each side of the wound, the double of the ligature is made to include the one, and the knot to press directly upon the other, instead of being made immediately on the edges of the fore, as was directed for interrupted sutures.

It is at once evident, however, that the ligatures must here make the same degree of pressure on the parts through which they pass as they do in the interrupted suture; and this being the case, it is equally obvious, that the interposition of these substances cannot be of any use. This suture is accordingly now very rarely practised, and it is probable that it will be soon laid entirely aside.

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Of the
twisted
suture.

By the term *twisted suture*, is meant that species of ligature by which parts, either naturally or artificially separated, are united together, by means of strong threads properly twisted round pins or needles pushed through the edges of the divided parts.

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Uses to
which it
may be put.

This suture is commonly employed for the purpose of uniting the parts in cases of hare-lip; and this indeed is almost the only use to which it has been hitherto applied: But it may with great advantage be put in practice in a variety of other cases, particularly in all artificial or accidental divisions either of the lips or cheeks; and in every wound in other parts that does not run deep, and in which sutures are necessary, this suture is preferable to the interrupted or any other. The pins made use of for twisting the threads upon ought to be made of a flat form, so as not to cut the parts through which they pass so readily as the ligatures employed in the interrupted suture. And thus one great objection to the latter is very effectually obviated: for every practitioner must be sensible of this being the most faulty part of the interrupted suture, that when muscular parts are divided so as to produce much retraction, the ligatures employed for retaining them almost constantly cut them through before a reunion is accomplished; whereas the flatness of the pins used in the twisted suture, and upon which the whole pressure produced by the ligatures is made to rest, proves in general a very effectual preventative against all such occurrences.

The pins used in this operation are represented in Plate CCCCLXXXVII. fig. 15. They are commonly made of gold or silver; and in order to make them pass with greater ease, steel points are added to them. They are sometimes used, however, of gold or silver alone.

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Method of
employing
the twisted
suture.

The manner of performing this operation is as follows. The divided parts intended to be reunited, must, by the hands of an assistant, be brought nearly into contact; leaving just as much space between the edges of the fore as to allow the surgeon to see that the pins are carried to a proper depth. This being done, one of the pins must be introduced through both sides of the wound, by entering it on one side externally, pushing it forwards and inwards to within a little of the bottom of the wound, and afterwards

carrying it outwardly through the opposite side, to the same distance from the edge of the fore that it was made to enter on the other.

The distance at which the needle ought to enter from the edge of the fore must be determined by the depth of the wound, and by the degree of retraction produced in the divided parts. In general, however, it is a proper regulation, in deep wounds, to carry the pins nearly to the same distance from the side of the fore as they are made to penetrate in depth: And whatever the deepness of the wound may be, the pins ought to pass within a very little of its bottom: otherwise the parts which lie deep will run a risk of not being united; a circumstance which must always give rise to troublesome collections of matter.

The first pin being passed in this manner very near to one end of the fore, and the parts being still supported by an assistant, the surgeon, by means of a firm waxed ligature, passed three or four times round and across the pin, so as nearly to describe the figure of 8, is to draw the parts through which it has passed into immediate and close contact: and the thread being now secured with a loose knot, another pin must be introduced in the same manner at a proper distance from the former; and the thread with which the other was fixed being loosed, and in the same manner carried round this pin, others must be introduced at proper distances along the whole course of the wound; and the same ligature ought to be of a sufficient length for securing the whole.

The number of pins to be used must be determined entirely by the extent of the wound. Whenever this suture is practised, a pin ought to be introduced very near each end of the wound, otherwise the extremities of the fore are apt to separate so as not to be afterwards easily reunited. In large wounds, if the pins are introduced at the distance of three quarters of an inch from one another, it will in general be found sufficient; but in cuts of smaller extent a greater number of pins become necessary in proportion to the dimensions of the fores.

Thus in a wound of an inch and half in length, three pins are absolutely requisite; one near to each end, and another in the middle of the fore: whereas five pins will always be found fully sufficient for a wound of three inches and a half in extent, allowing one to be within a quarter of an inch of each extremity of the wound, and the others to be placed along the course of the fore at the distance of three quarters of an inch from one another.

The pins being all introduced and secured in the manner directed, nothing remains to be done, but to apply a piece of lint wet with mucilage all along the course of the wound, with a view to exclude, as effectually as possible, every access to the external air.

When the pins remain long, they generally do harm, by the unnecessary irritation and consequent retraction of parts with which they are always attended; and if they are not continued for a sufficient length of time, that degree of adhesion is not produced between the divided parts which is necessary for their future retention; so that the effect of the operation comes to be in a great measure, if not entirely, lost.

In wounds of no great depth, for instance of three quarters of an inch or so, a sufficient degree of adhesion always takes place in the space of five days; and six, or at most seven days, will generally be found sufficient for wounds of the greatest depth. But with respect to this circumstance, it must always be understood, that the patient's state of health must have a considerable influence on the time necessary for producing adhesion between divided parts.

When the pins are withdrawn, the uniting bandage may be

Sutures.

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Number of
pins to be
used.

¹⁶⁰ ^{Ligature of Arteries.} be applied with great advantage; but as slips of leather spread with ordinary glue, when applied to each side of the cicatrix, may, by means of ligatures properly connected with them, be made to answer the purpose more effectually, this mode of supporting the parts ought of course to be preferred.

SECT. II. *Of the Ligature of Arteries.*

WHEN a surgeon is called immediately to a wound of any great artery of a limb, he should clap the point of his finger upon the wounded artery, or make his assistant hold it; cut the wound so far open as to see the artery fairly; draw it out if it be cut across, and have shrunk among the flesh; or tie it like the artery of the arm in aneurism by passing ligatures under it. When, however, the wound happens in such situations that we cannot command the blood, it is better to close the lips of the wound, and try to make them adhere by means of a very steady compress and bandage. Thus an aneurism will form; the operation for the cure of which shall be afterwards described.

When accidents of this nature occur in any of the extremities, and where pressure can be made with ease on the superior part of the artery, we are possessed of an instrument which never fails to put a stop to all further loss of blood: we mean the tourniquet. See Plate CCCCLXXXVII. fig. 16.

¹⁶⁰ ^{The tourniquet.} The tourniquet has undergone many improvements; but the one here represented is considered as the best. By means of it the blood in any limb is very easily and effectually commanded; and as it grasps the whole member equally, all the collateral branches, as well as the principal arteries, are equally compressed by it. It has this material advantage too over every other instrument of this kind, that, when properly applied, a single turn, or even half a turn, of the screw, is sufficient for producing either a flow of blood, or for putting a total stop to it. The manner of using it is as follows.

¹⁶¹ ^{Manner of using it.} Let a cushion of three inches in length by one inch and half in diameter be prepared of a linen roller, tolerably firm, but not so hard as to render pressure produced by it very painful. This being placed upon the course of the principal artery of the limb, is to be firmly secured in that situation by one or two turns of a circular roller, of the same breadth with the cushion itself.

The instrument, with the strap connected with it, being now placed upon the limb, with the handle of the screw on the opposite side of the member to the cushion upon the artery, the strap is to be carried round the limb directly over the cushion, and to be firmly connected on the other side of the buckle. In thus connecting the strap and buckle together, particular attention is necessary in doing it with great firmness, so as that the screw may afterwards operate with as much advantage as possible in producing a sufficient degree of pressure. When proper attention is paid to this circumstance, a single turn of the screw proves sufficient for putting an entire stop to the circulation of blood in the limb: but when the strap has not originally been made very tight, several turns of the screw become necessary; an occurrence which may be always very easily prevented, and which, when not attended to, frequently proves very embarrassing in the course of an operation.

¹⁶² ^{Method of tying arteries by means of the tenaculum.} Various methods have been invented for securing arteries by means of ligatures. The practice till lately in ordinary use was, by means of a curved needle, to pass a ligature of sufficient strength round the mouth of the bleeding vessel, including a quarter of an inch all round of the surrounding parts, and afterwards to form a knot of a proper tightness upon the vessel and other parts comprehended in the noose.

But this method was found to give so much pain, and in some cases to be attended with such violent convulsions, not only in the part chiefly affected, but of the whole body, that the best practitioners have thought proper to reject it, and to tie up the blood-vessels by themselves; for it is now well known that even very small arteries are possessed of much firmness; and that even in the largest arteries a slight degree of compression is sufficient not only for restraining hemorrhagy, but for securing the ligature on the very spot to which it is first applied.

In order to detect the arteries to be tied, the tourniquet, with which they are secured, must be slackened a little by a turn or two of the screw; and the moment the largest artery of the fore is discovered, the surgeon fixes his eye upon it, and immediately restrains the blood again by means of the tourniquet. An assistant now forms a noose on the ligature to be made use of; and this noose being put over the point of the tenaculum, Plate CCCCLXXXVII. fig. 17. the operator pushes the sharp point of the instrument through the sides of the vessel, and at the same time pulls so much of it out, over the surface of the surrounding parts, as he thinks is sufficient to be included in the knot which the assistant is now to make upon the artery. In forming this ligature a single knot moderately drawn, and over it another single knot, is perfectly sufficient.

¹⁶³ ^{With the crooked needle.} When from the deepness of a wound, or from any other cause, some particular artery cannot be properly secured by the tenaculum; in this case there is a necessity of employing the crooked needle, and the following is the method of using it.

A needle of the shape represented Pl. CCCCLXXXVII. fig. 14. armed with a ligature of a size proportioned to itself and to the vessel to be taken up, is to be introduced at the distance of a sixth or eighth part of an inch from the artery, and pushed to a depth sufficient for retaining it, at the same time that it is carried fully one half round the blood-vessel. It must now be drawn out; and being again pushed forward till it has completely encircled the mouth of the artery, it is then to be pulled out; and a knot to be tied of a sufficient firmness, as was already directed when the tenaculum is used.

CHAP. XI. *Of Aneurisms.*

¹⁶⁴ ^{Definition.} THE term *Aneurism* was originally meant to signify a tumor formed by the dilatation of the coats of an artery; but by modern practitioners it is made to apply not only to tumors of this kind, but to such as are formed by blood effused from arteries into the contiguous parts. There are three species; the true or encysted, the false or diffused, and the varicose aneurism.

¹⁶⁵ ^{The true or encysted aneurism.} The *true* or *encysted* aneurism, when situated near the surface of the body, produces a tumor at first small and circumscribed; the skin retains its natural appearance; when pressed by the fingers, a pulsation is evidently distinguished; and with very little force the contents of the swelling may be made to disappear; but they immediately return upon removing the pressure. By degrees the swelling increases, and becomes more prominent; but still the patient does not complain of pain: on pressure the tumor continues of an equal softness, and is compressible. After this the swelling becomes large, the skin turns paler than usual, and in more advanced stages œdematous: the pulse still continues; but parts of the tumor become firm from the coagulation of the contained blood, and yield little to pressure; at last the swelling increases in a gradual manner, and is attended with a great degree of pain. The skin turns livid, and has a gangrenous appearance. An oozing of bloody

Aneurisms. bloody serum occurs from the integuments; and, if a real mortification do not take place, the skin cracks in different parts; and the artery being now deprived of the usual resistance, the blood bursts out with such force as to occasion the almost immediate death of the patient. Thus the disease terminates in the large cavities of the body; but in the extremities we can, by means of the tourniquet, prevent the sudden termination of the disease.

When affections of this kind happen in the larger arteries, the effects produced upon the neighbouring parts are often surprising: the soft parts not only yield to a great extent, but even the bones frequently undergo a great degree of derangement.

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The false or
diffuse
aneurism.

The *false* or *diffuse* aneurism consists in a wound or rupture in an artery, producing, by the blood thrown out of it, a swelling in the contiguous parts. It is most frequently produced by a wound made directly into the artery.

The following is the usual progress of the disorder. A tumor, about the size of a horse-bean, generally rises at the orifice in the artery soon after the discharge of the blood has been stopped by compression. At first it is soft, has a strong degree of pulsation, and yields a little to pressure, but cannot be made entirely to disappear; for here the blood forming the tumor being at rest, begins to coagulate. If not improperly treated by much pressure, it generally remains nearly of the same size for several weeks. The enlargement however proceeds more rapidly in some cases than in others. Instances have occurred of the blood being diffused over the whole arm in the space of a few hours; while, on the contrary, swellings of this kind have been many months, nay even years, in arriving at any considerable size.

As the tumor becomes larger, it does not, like the true aneurism, grow much more prominent, but rather spreads and diffuses itself into the surrounding parts. By degrees it acquires a firm consistence; and the pulsation, which was at first considerable, gradually diminishes, till it is sometimes scarcely perceptible. If the blood at first thrown out proceed from an artery deeply seated, the skin preserves its natural appearance till the disorder is far advanced: but when the blood gets at first into contact with the skin, the parts become instantly livid, indicating the approach of mortification; and a real sphacelus has sometimes been induced. The tumor at first produces little uneasiness; but as it increases in size, the patient complains of severe pain, stiffness, numbness, and immobility of the whole joint; and these symptoms continuing to augment, if the artery be large, and assistance not given, the teguments at last burst, and death must ensue.

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Varicose
aneurism.

When an artery is punctured through a vein, as in blood-letting at the arm, the blood generally rushes into the yielding cellular substance, and there spreads so as to shut the sides of the vein together. But in some instances where the artery happens to be in contact with the vein, the communication opened has been preserved; and the vein not being sufficiently strong for resisting the impulse of the artery, must consequently be dilated. This is a varicose aneurism. It was first accurately described by Dr Hunter, and since that time has been frequently observed by different practitioners. Here the swelling is entirely confined to the vein. Soon after the injury the vein immediately communicating with the artery begins to swell, and enlarge gradually. If there be any considerable communications in the neighbourhood, the veins which form them are also enlarged. The tumor disappears upon pressure, the blood contained in it being chiefly pushed forwards in its course towards the heart; and when the tumor is large, there is a singular tremulous motion, attended with

a perpetual hissing noise, as if air was passing into it through a small aperture.

If a ligature be applied upon the limb immediately below the swelling, tight enough to stop the pulse in the under part of the member, the swelling disappears by pressure, but returns immediately upon the pressure being removed. If, after the swelling is removed by pressure, the finger be placed upon the orifice in the artery, the veins remain perfectly flaccid till the pressure is taken off. If the trunk of the artery be compressed above the orifice so as effectually to stop the circulation, the tremulous motion and hissing immediately cease; and if the veins be now emptied by pressure, they remain so till the compression upon the artery be removed. If the vein be compressed a little above, as well as below the tumor, all the blood may generally, though not always, be pushed through the orifice into the artery; from whence it immediately returns on the pressure being discontinued.

When the disease has continued long, and the dilatation of the veins has become considerable, the trunk of the artery above the orifice generally becomes greatly enlarged, while that below becomes proportionably small; of consequence the pulse in the under part of the member is always more feeble than in the sound limb of the opposite side.

The causes producing aneurisms, in general, are a natural disease of the arteries. Thus a partial debility of their coats may readily produce the disease; or they may arise, especially in the internal parts of the body, from great bodily exertions. They are likewise produced by wounds of the coats of the arteries, as now and then happens in blood-letting at the arm; or from acrid matter contained in a neighbouring fore; or from the destruction of surrounding parts, by which the natural support is removed.

Aneurisms have frequently been mistaken for abscesses and other collections of matter, and have been laid open by incision; on which account great attention is sometimes required to make the proper distinction. In the commencement of the disease the pulsation in the tumor is commonly so strong, and other concomitant circumstances so evidently point out the nature of the disorder, that little or no doubt respecting it can ever take place; but in the more advanced stages of the disease, when the swelling has become large and has lost its pulsation, nothing but a minute attention to the previous history of the case can enable the practitioner to form a judgment of its nature.

Aneurisms may be confounded with soft encysted tumors, serophulous swellings, and abscesses situated so near to an artery as to be affected by its pulsation. But one symptom, when connected with strong pulsation, may always lead to a certain determination that the swelling is of the aneurismal kind, viz. the contents of the tumor being made easily to disappear upon pressure, and their returning on the compression being removed. The want of this circumstance, however, ought not to convince us that it is not of that nature; for it frequently happens, especially in the advanced stages of aneurisms, that their contents become so firm that no effect is produced upon them by pressure. Hence the propriety, in doubtful cases, of proceeding as if the disease was clearly of the aneurismal kind.

In the prognosis, three circumstances are chiefly to be attended to; the manner in which the disease appears to have been produced, the part of the body in which the swelling is situated, and the age and habit of the body of the patient.

If an aneurism has come forward in a gradual manner, without any apparent injury done to the part, and not succeeding any violent bodily exertion, there will be reason to suppose

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Causes of
aneurism.

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Diagnosis.

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Prognosis.

Aneurism. suppose that the disease depends upon a general affection either of the trunk in which it occurs, or of the whole arterious system. In such cases art can give little assistance: whereas if the tumor has succeeded an external accident, an operation may be attended with success.

171 An operation seldom necessary in varicose aneurism. In the varicose aneurism a more favourable prognosis may generally be given than in either of the other two species. It does not proceed so rapidly; when it has arrived at a certain length, it does not afterwards acquire much additional size; and it may be sustained without much inconvenience for a great number of years. As long as there is reason to expect this, the hazard which almost always attends the operation ought to be avoided.

In the second volume of the London Medical Observations, two cases are related by Dr Hunter of the varicose aneurism. One of them at that time was of 14 years standing, and the other had subsisted for five years, without there being any necessity for an operation. And in vol. iii. of the same work a similar case of five years duration is related by Dr Cleghorn.

In a letter afterwards from Dr Hunter to Mr Benjamin Bell, the Doctor says, "The lady in whom I first observed the varicose aneurism is now living at Bath in good health, and the arm is in no sense worse, although it is now 35 years since she received the injury:" and the Doctor farther observes, that he never heard of the operation being performed for the varicose aneurism which was known to be such.

Mr Bell says, he was informed by Dr William Cleghorn of Dublin, that the case of varicose aneurism, related in the 3d volume of the London Medical Observations, remained nearly in the same state as at the time that account of it was made out, which included a period of at least 20 years; only that the veins were rather more enlarged. The patient recovered, and the limb became nearly as strong and serviceable as the other. Mr Pott also met with three different instances of this species of aneurism; and observes, that the operation never became necessary in any of them.

Among other instances of varicose aneurism which have appeared here, a young man from Paisley was examined several years ago by different surgeons of this place. The disease was very clearly marked, and no operation was advised. He was afterwards found serving in the navy, where he underwent great fatigue without any inconvenience from the aneurism, though then of 13 years standing.

But though this aneurism, when it has arrived at a certain size, commonly remains stationary, and may be borne without much inconvenience for a long time, this is not always the case; for some instances have occurred, where the disease was attended with great uneasiness, and where the operation was performed with much difficulty.

In judging further of the probable event of aneurisms in general, the situation of the tumor next requires attention. When it is so situated that no ligature or effectual compression can be applied for stopping the circulation in the part, if the artery be large, there would be the greatest danger in opening it. In this case therefore the most fatal consequences are to be apprehended.

When aneurisms are situated near the upper parts of the extremities, surgeons have been hitherto doubtful whether, after tying up the humeral or femoral arteries, the lower parts of the limb would be supplied with blood; and tho' several successful instances of performing that operation have been published, the success has been pretty generally ascribed to unusual branching of the great arteries of those patients, on whom the operation was performed, above the aneurism. Mr John Bell, however, in his late very inge-

nious and important *Discourses on Wounds*, has proved, to our satisfaction at least, that the inoculations which take place between the internal iliac and the arteries of the leg, by means of the glutæal arteries and the profunda femoris, are in every case sufficient to supply nourishment to the limb; that the same is the case in the arm; and that therefore in every aneurism, even of the humeral or femoral artery, we ought to perform the operation. Several instances of success are there related; among others, an operation performed by Mr J. Bell himself, which, as it is perhaps the greatest that has hitherto been performed, we shall here abridge for the gratification of our readers. A leech-catcher fell as he was stepping out of a boat; and a pair of long-pointed scissors pierced his hip exactly over the sciatic notch, where the great iliac artery comes out from the pelvis. The artery bled furiously: the patient fainted. The surgeon easily stopt up the wound, as it was very narrow and deep, and healed it. A great tumor soon formed. The man travelled from the north country in six weeks to the Edinburgh infirmary, with a prodigious tumor of the hip, the thigh rigidly contracted, the ham bent, the whole leg shrunk and cold and useless. There was no pulsation nor retrocession of blood on pressure; but the distension was attended with great pain, and the man was extremely anxious to have an operation performed. Though there was little doubt of its being aneurism, it might be a great abscess. It was resolved therefore to make a small incision, and just touch the bag with the point of a lancet, and if it contained blood, a full consultation was to be called. Mr Bell accordingly made an incision two inches and an half in length; the great fascia formed the coat of the tumor, and under it were seen the fibres of the great glutæus muscle. As soon as it was opened at one point, great clots of blood came out; and Mr Bell, after being certain that it was an aneurism of the great artery of the thigh, closed up the wound with a tent-like compress, put the patient to bed, and a pupil held his hand on the hip. This was done at one o'clock; at four the consultation met, and the operation was performed. On making an incision eight inches long, the blood was thrown out with a whishing noise, and with such impetuosity, that the assistants were covered with it. In a moment twenty hands were about the tumor, and the bag was filled with sponges and cloths of all kinds; the blood, however, still made its way; and the man who had supported himself on his elbow, fell down; his arms and head hung down, he uttered two or three heavy groans, and they thought him dead. At that critical moment Mr Bell ran the bistoury upwards and downwards, and at once made the wound two feet long; thrust his hand to the bottom of the tumor, felt the warm jet of blood, put his finger on the mouth of the artery, the pulse of which he felt distinctly; which first assured him that the man was alive. The artery was then tied; and when Mr Bell lifted up his finger, it was discovered to be the posterior iliac; that it had been cut fairly across, and had bled with open mouth. The patient was so low, that after dressing the wound, they were obliged to bring in a bed, and leave him to sleep in the operation room. He was cured of this great wound in less than seven months, and afterwards recovered the use of his leg completely.

173 In every case of aneurism, the use of pressure has been indiscriminately recommended, not only in the incipient period of the disease, but even in its more advanced stages.

In the diffused or false aneurism, as pressure cannot be applied to the artery alone, without at the same time affecting the reflux veins; and as this, by producing an increased resistance to the arterial pulsations, must force an additional quantity of blood to the orifice in the artery—no advantage

Aneurism.
Part I.
Disc. 2.

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Remark.
able aneu-
rism.

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Effects of
pressure in
aneurisms.

Aneurism is to be expected from it, though it may be productive of mischief.

In the early stages of encysted aneurism, while the blood can be yet pressed entirely out of the sac into the artery, it often happens, by the use of a bandage of soft and somewhat elastic materials, properly fitted to the part, that much may be done in preventing the swelling from receiving any degree of increase; and on some occasions, by the continued support thus given to the weakened artery, complete cures have been at last obtained. In all such cases, therefore, particularly in every instance of the varicose aneurism, much advantage may be expected from moderate pressure.

But pressure, even in encysted aneurism, ought never to be carried to any great length; for tight bandages, by producing an immoderate degree of reaction in the containing parts to which they are applied, instead of answering the purpose for which they were intended, have evidently the contrary effect. Indeed the greatest length to which pressure in such cases ought to go, should be to serve as an easy support to the parts affected, and no farther.

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Method of
performing
the opera-
tion for
aneurism.

In performing the operation for aneurism, the first step ought to be to obtain a full command of the circulation in the inferior part of the member by means of the tourniquet. This being done, the patient should be so placed, that the diseased limb, on being stretched on a table, is found to be of a proper height for the surgeon; who, as the operation is generally tedious, ought to be seated. The limb being properly secured by an assistant, the operator is now with the scalpel, Plate CCCCLXXXVII. fig. 18. to make an incision through the skin and cellular substance along the whole course of the tumor; and as freedom in the remaining parts of the operation is here a matter of much importance, it is even of use to carry this external incision half an inch or so both above and below the farthest extremities of the swelling.

All the effused blood ought then to be wiped off by means of a sponge; and the softest part of the tumor being discovered, an opening ought there to be made into it with the lancet, Plate CCCCLXXXVII. fig. 19. large enough for admitting a finger of the operator's left-hand. This being done, and the finger introduced into the cavity of the tumor, it is now to be laid open from one extremity to the other, by running a blunt-pointed bistoury, Plate CCCCLXXXVII. fig. 20. along the finger from below upwards, and afterwards from above downwards, so as to lay the whole cavity fairly open.

The cavity of the tumor being thus laid freely open, all the coagulated blood is to be taken out by the fingers of the operator, together with a number of tough membranous filaments commonly found here. The cavity of the tumor is now to be rendered quite dry, and free from the blood which, on the first opening of the swelling, is discharged into it from the veins in the inferior part of the member: the tourniquet is then to be slackened to discover, not only the artery itself, but the opening into it, from whence the blood collected in the tumor has been all along discharged. This being done, the next point to be determined is the manner of securing this opening into the artery, so as to prevent in future any farther effusion of blood. Various means have been proposed for accomplishing this; but the effects of all of them may be comprehended under the three following heads.

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Method of
securing
the wound
of the ar-
tery,

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By astrin-
gents,

1. The effects of ligature upon a large artery having on some occasions proved fatal to the inferior part of the member, it was long ago proposed, that so soon as the opening into the artery has been discovered, instead of applying a ligature round it, which for certain is to obliterate its ca-

vity entirely, a piece of agaric, vitriol, alum, or any other astringent substance, should be applied to the orifice, in order if possible to produce a reunion of its sides.

2. Upon the same principle with the preceding, viz. that of still preserving the circulation in the artery, it was several years ago proposed by an eminent surgeon of Newcastle, Mr Lambert, that the orifice in the artery should be secured by means of the twisted suture. A small needle being pushed through the edges of the wound, they are then directed to be drawn together by a thread properly twisted round the needle, as was formerly directed when treating of sutures.

Strong objections, however, occur to both of these methods. In the first place, no astringent application with which we are acquainted is possessed of such powers as to deserve much confidence. In almost every instance in which they have been used, the hemorrhage has recurred again and again, so as to prove very distressing, not only to the patient, but to the practitioner in attendance; little or no attention is therefore to be paid to remedies of this kind in ordinary practice.

Mr Lambert's method of stitching the orifice in the artery is certainly a very ingenious proposal; and would in all probability, at least in most instances, prove an effectual stop to all farther discharge of blood: but as we have yet only one instance of its success, little can be said about it. Two material objections, however, seem to occur to this practice. One is, that in the operation for the aneurism, in almost every instance, a very few only excepted, the artery lies at the back-part of the tumor; so that when all the collected blood is removed, there is such a depth of wound, that it must be always a very difficult matter, and on many occasions quite impracticable, to perform this nice operation upon the artery with that attention and exactness which, in order to ensure success, it certainly requires. But there is another very material objection. By introducing a needle through the sides of the orifice, and drawing these together by a ligature, the cavity of the artery must undoubtedly be at that point much diminished. Indeed Mr Lambert, in his account of the case in which this operation was performed, acknowledges that the diameter of the artery was thereby diminished. Now the passage of the blood being thus contracted at one point, the impulse upon that particular part must be very considerable: So that the very remedy employed for the cure of one species of aneurism, will in all probability prove a very powerful agent in inducing another; for the blood being thus obstructed in its usual course, there will be no small danger incurred of a dilatation being produced immediately above this preternatural stricture.

3. Neither of the methods we have yet been considering being found eligible for securing the orifice in the artery, we shall now proceed to describe the ordinary manner of performing this operation; which consists in obliterating the arterial cavity entirely by means of ligatures.

The artery being laid bare in the manner directed, and all the coagulated blood being carefully removed from the cavity of the tumor, on the tourniquet being now slackened so as to bring the orifice in the artery into view, a small probe curved at the extremity is to be introduced at the opening, in order to raise the artery from the neighbouring parts, so as that the surgeon may be enabled with certainty to pass a ligature round it, without comprehending the contiguous nerves, which in general run very near to the large blood-vessels of a limb. By this precaution the nerves may be always avoided; and by doing so, a great deal of mischief may be prevented, which otherwise might supervene. When the disorder is situated either in the ham, or in the usual part of blood-letting in the arm, bending the joints of

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Method of
doing it by
ligature.

Aneurism. the knee or of the elbow, as it relaxes the artery a little, renders this part of the operation more easily effected than when the limbs are kept fully stretched out.

The artery being thus gently separated from the contiguous parts, a firm waxed ligature must be passed round it, about the eighth part of an inch or so above the orifice, and another must in the same manner be introduced at the same distance below it.

The ligatures being both finished in the manner directed, the tourniquet is now to be made quite loose; and if no blood is discharged at the orifice in the artery, we may then rest satisfied that the operation is so far properly completed.

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Subsequent treatment of the patient. The wound is now to be lightly covered with soft lint, with a pledgit of any emollient ointment over the whole; and a compress of linen being applied over the dressings, all the bandage in any degree requisite is two or three turns of a roller above and as many below the centre of the wound, making it press with no more tightness than is absolutely necessary for retaining the application we have just now mentioned.

The patient being now put into bed, the member should be laid in a relaxed posture upon a pillow, and ought to be so placed as to create the least possible uneasiness from the posture in which it is laid.

As the operation for the aneurism is always tedious, and produces much pain and irritation, a full dose of laudanum should be given immediately on the patient being got into bed. In order to diminish sensibility during some of the more capital operations, different trials have been made of opiates given an hour or so before the operation. On some occasions this proved evidently very useful; but in others it seemed to have the contrary effect; particularly in weak nervous constitutions, in which with any doses, however small, they appeared to be rendered more irritable and more susceptible of pain, than if no opiate had been given. Immediately after this operation, however, an opiate ought to be exhibited, to be repeated occasionally according to the degrees of pain and restlessness.

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State of the limb after the operation. In some few cases of aneurism, it has happened that the pulse in the under part of the member has been discovered immediately after the operation. This, however, is a very rare occurrence: For as this disorder is seldom met with in any other part than at the joint of the elbow as a consequence of blood-letting, and as it rarely happens that the brachial artery divides till it passes an inch or two below that place, the trunk of this artery is therefore most frequently wounded; and when, accordingly, the ligature, in this operation, is made to obliterate the passage of almost the whole blood which went to the under part of the arm, there cannot be the least reason to expect any pulsation at the wrist, till in a gradual manner the anastomosing branches of the artery have become so much enlarged as to transmit such a quantity of blood to the inferior part of the member as is sufficient for acting as a stimulus to the larger branches of the artery.

Immediately after the operation, the patient complains of an unusual numbness or want of feeling in the whole member; and as it generally, for a few hours, becomes cold, it is therefore right to keep it properly covered with warm soft flannel; and in order to serve as a gentle stimulus to the parts below, moderate frictions appear to be of use. In the space of ten or twelve hours from the operation, although the numbness still continues, the heat of the parts generally begins to return; and it frequently happens, in the course of a few hours more, that all the inferior part of the member becomes even preternaturally warm.

Immediately after this operation, the want of feeling in

the parts is often very great; and in proportion as the circulation in the under part of the member becomes more considerable, the degree of feeling also augments. If we could suppose the nerves of the parts below to be always included in the ligature with the artery, that numbness which succeeds immediately to the operation might be easily accounted for; but it has been also known to happen when nothing but the artery was secured by the ligature.

In the mean time, the patient being properly attended to as to regimen, by giving him cordials and nourishing diet when low and reduced, and confining him to a low diet if his constitution is plethoric, the limb being still kept in an easy relaxed posture, towards the end of the fourth or fifth day, sometimes much sooner, a very weak feeble pulse is discovered in the under part of the member, which becoming stronger in a gradual manner, the patient in the same proportion recovers the use and feeling of the parts.

So soon as there is an appearance of matter having formed freely about the sore, which will seldom happen before the fifth or sixth day, an emollient poultice should be applied over it for a few hours, in order to soften the dressings, which may be then removed. At this time the ligatures might be taken away; but as their continuance for a day or two longer can do no harm, it is better to allow them to remain till the second or third dressing, when they either drop off themselves, or may be taken away with perfect safety. The dressings, which should always be of the softest materials, being renewed every second or third day according to the quantity of matter produced, the sore is in general found to heal very easily; and although the patient may for a considerable time complain of great numbness and want of strength in the whole course of the diseased limb, yet in most instances a very free use of it is at last obtained.

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Very often after the artery seems to be secured it gives Hemorrhage, way, and fatal hemorrhagies ensue; nor is the patient free from this danger for a great length of time. In one of Mr Hunter's operations the artery gave way on the 26th day. It is to this difficulty of procuring adhesion between the sides of the artery that a great part of the danger of this operation is to be ascribed.

CHAP. XII. *Of Affections of the Brain from External Violence.*

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WHEN the brain is compressed, a set of symptoms ensue extremely dangerous, though sometimes they do not make their appearance till after a considerable interval. But at whatever time they appear, they are uniformly of the same kind, and are in general as follow: drowsiness, giddiness, and stupefaction, dimness of sight, dilatation of the pupil; and, where the injury done to the head is great, there is commonly a discharge of blood from the eyes, nose, and ears. Sometimes the fractured bone can be discovered through the integuments, at others it cannot. There is an irregular and oppressed pulse, and snoring or apoplectic stertor in breathing. There is likewise nausea and vomiting, with an involuntary discharge of feces and urine. Among the muscles of the extremities and other parts, there is loss of voluntary motion, convulsive tremors in some parts of the body, and palsy in others, especially in that side of the body which is opposite to the injured part of the head.

Some of the milder of these symptoms, as vertigo, stupefaction, and a temporary loss of sensibility, are frequently induced by slight blows upon the head, but commonly soon disappear, either by rest alone, or by the means to be afterwards pointed out. But when any other symptoms ensue, such as dilatation of the pupils, and especially when much blood is dis-

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and Depres-
sion of the
Cranium,
&c.

discharged from the eyes, nose, and ears, and that there is an involuntary discharge of feces and urine, it may be reasonably concluded that compression of the brain is induced.

The cavity of the cranium, in the healthy and natural state, is everywhere completely filled by the brain; whatever therefore diminishes that cavity, will produce a compression of the brain.

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Causes of
these.

The causes producing such a diminution may be of various kinds, as fracture and depression of the bones of the cranium; the forcible introduction of any extraneous body into the cavity of the cranium; effusion of blood, serum, pus, or any other matter; the thickness of the bones of the cranium in certain diseases, as in lues venerea, rickets, or spina ventosa; or water collected in hydrocephalous cases. The first set of causes shall be considered in their order. The four last mentioned belong to the province of the physician, and have been considered in a former part of this Work.

SECT. I. *Of Fracture and Depression of the Cranium producing Compression of the Brain.*

FRACTURES of the cranium have been differently distinguished by different authors; but it seems sufficient to divide them into those attended with depression, and those which are not so.

In fracture and depression of the cranium, the treatment ought to be,—to discover the situation and extent of the fracture;—to obviate the effects of the injury done to the brain, by raising or removing all the depressed parts of the bone;—to endeavour to complete the cure by proper dressings, and attention to the after treatment.

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Method of
discovering
the situa-
tion of frac-
tures of the
cranium.

When the teguments corresponding to the injury done to the bone are cut or lacerated, and, as is sometimes the case, entirely removed, the state of the fracture is immediately discovered; but when the integuments of the skull remain entire, even though the general symptoms of fracture be present, there is sometimes much difficulty in ascertaining it. When, however, any external injury appears, particularly a tumor from a recent contusion, attended by the symptoms already described, there can be no doubt of the existence of a fracture. But it sometimes happens that compression exists without the smallest appearance of tumor. In such cases, the whole head ought to be shaved, when an inflammatory spot may frequently be observed. Sometimes the place of the fracture has been discovered by the patient applying the hand frequently on or near some particular part of the head.

When the symptoms of a compressed brain are evidently marked, no time ought to be lost in setting about an examination of the state of the cranium, wherever appearances point out, or even lead us to conjecture, in what part a fracture may be situated. For this purpose an incision is to be made upon the spot through the integuments to the surface of the bone, which must be sufficiently exposed to admit of a free examination.

Some authors have recommended a crucial incision; others one in form of the letter T; while many advise a considerable part of the integuments to be entirely removed. But as it is more agreeable to the present mode of practice to save as much of the skin as possible, a simple incision is generally preferred, unless the fracture run in different directions, and then the incision must vary accordingly. It will frequently happen, that a considerable part of the integuments must be separated from the skull, in order to obtain a distinct view of the full extent of the fracture; but no part of the integuments is to be entirely removed.

When blood-vessels of any considerable size are divided, either before or in time of the examination, they ought to be allowed to bleed freely, as in no case whatever is the loss of blood attended with more advantage than the present.

When, however, it appears that the patient has lost a sufficient quantity, the vessels ought to be secured.

After the integuments have been divided, if the skull be found to be fractured and depressed, the nature of the case is rendered evident; but even where there is no external appearance of fracture, tumor, discoloration, or other injury, if the patient continue to labour under symptoms of a compressed brain, if the pericranium has been separated from the bone, and especially if the bone has lost its natural appearance, and has acquired a pale white or dusky yellow hue, the trepan ought to be applied without hesitation at the place where these appearances mark the principal seat of the injury.

Again, although no mark either of fracture or of any diseases underneath should appear on the outer table of the bone, yet there is a possibility that the inner table may be fractured and depressed. This indeed is not a common occurrence, but it happens probably more frequently than surgeons have been aware of; and where it does happen, the injury done to the brain is as great, and attended with as much danger, as where the whole thickness of the bone is beat in. The application of the trepan is therefore necessary.

But if, after the application of the trepan, it happens that no mark of injury appears either in the outer or inner table in that part, or in the dura mater below it, and that the symptoms of a compressed brain still continue, a fracture in some other part is to be suspected; or that kind of fracture termed by practitioners *counter fissure*, where the skull is fractured and sometimes depressed on the opposite side to, or at a distance from, the part where the injury was received. This is fortunately not a very frequent occurrence, and has even been doubted by some; but different instances of it have, beyond all question, been found. If therefore the operation of the trepan has been performed, and no fracture is discovered, no extravasation appears on the surface of the brain; and if blood-letting and other means usually employed do not remove the symptoms of compression, the operator is to search for a fracture on some other part. The whole head should again be examined with much accuracy; and, by pressing deliberately but firmly over every part of it, if the smallest degree of sensibility remains, the patient will show signs of pain, either by moans or by raising his hands, when pressure is made over the fractured part. In this way fractures have been frequently detected, which might otherwise have been concealed.

Having now considered every thing preparatory to the operation of the trepan, we shall next point out the means best adapted for the removal or elevation of a depressed portion of the bone.

The first thing to be done is, after shaving the head, to make an incision as deep as the bone, and directly upon the course of the fracture.

The patient ought to be laid on a table, with a mattress under him, while his head is placed upon a pillow, and secured by an assistant. When the extent of the fracture has been determined, and the bleeding from the incision stopped, the depressed bone is now to be elevated; but previous to this it is necessary to search for detached pieces. Should any be found, they ought to be removed by a pair of forceps adapted to this purpose. By the same instrument any splinters of bone which may have been beaten in may be removed; but when a part of the bone is beaten in beyond the level of the rest of the cranium, as much of the pericranium is then to be removed by a raspator, Plate CCCCLXXXVIII. fig. 21. as will allow the trephine, Plate CCCCLXXXVIII. fig. 22. to be applied; or, if the operator incline, for the sake of dispatch, he may use the trepan,

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Plate

Fracture
and Depres-
sion of the
Cranium,
&c.

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Method of
removing
and elevat-
ing depres-
sed portions
of the cra-
nium.

Fracture
and Depres-
sion of the
Cranium,
&c.

Fracture
and Depres-
sion of the
Cranium,
&c.

Plate CCCCLXXXVIII. fig. 23. and 24.; or the operation may be begun and finished with the trephine, while the trepan may perform the middle and principal part of the work. This part of the work is begun by making a hole with the perforator (fig. 24.), which is screwed on to the lower end of fig. 23. deep enough to fix the central pin of the trephine, in order to prevent the saw from slipping out of its central course, till it has formed a groove sufficiently deep to be worked steadily in; and then the pin is to be removed. If the bone be thick, the teeth of the saw must be cleaned now and then by the brush (fig. 25.) during the perforation, and dipped in oil as often as it is cleaned, which will considerably facilitate the motion, and render it more expeditious; making it at the same time much less disagreeable to the patient, if he possess his senses. That no time may be lost, the operator ought to be provided with two instruments of the same size, or at least to have two heads which can be readily fitted to the same handle.

After having made some progress in the operation, the groove ought to be frequently examined with a pick-tooth, or some such instrument, in order to discover its depth; and if one side happen to be deeper than the other, the operator ought to press more on that side which is shallowest. Precautions are more particularly necessary when the operation is performed upon a part of the skull which is of an unequal thickness, especially after the instrument has passed the diploe. And though it be said by writers in general that the instrument may be worked boldly till it comes at the diploe (which is generally known by the appearance of blood), yet the operator should be upon his guard in this point, examining from time to time if the piece be loose, lest thro' inadvertence the dura mater be wounded; for in some parts of the skull there is naturally very little diploe, and in old subjects scarcely any. It ought likewise to be remembered, that the skulls of children are very thin. When the piece begins to vacillate, it ought to be snapped off with the forceps (fig. 26.), or levator (fig. 26. a); for the sawing ought by no means to be continued till the bone be cut quite through, otherwise the instrument may plunge in upon the brain, or at least injure the dura mater. If the inner edge of the perforation be left ragged, it is to be smoothed with the lenticular (fig. 28. b), to prevent it from irritating the dura mater. Particular care is to be taken in using the instrument, lest it should press too much upon the brain.

The next step is to raise the depressed part of the bone with the levator, or to extract the fragments of the bone, grumous blood, or any extraneous body. After this, if there appear reason to apprehend that blood, lymph, or matter, is contained under the dura mater, it ought to be cautiously opened with a lancet, endeavouring to avoid the blood-vessels running upon it, or lying immediately under it.

When the trepan is to be used on account of a fissure in which the bone will not yield, the instrument should be applied so as to include part of it, if not directly over it, as it is most probable that the extravasated fluid will be found directly under it. And when the fissure is of great extent, it may be proper to make a perforation at each end, if the whole can be conveniently brought into view; and in some cases several perforations may become necessary.

When it is proposed to make several perforations to remove depressed fragments of the bone which are firmly fixed, and having the internal surface larger than the external, or to raise them sufficiently, it is necessary to apply the trepan as near the fractured parts as possible; making the perforations join each other, to prevent the trouble of cutting the intermediate spaces.

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When the skull is injured over a future, and it is not thought advisable to use the trepan, a perforation ought to be made on each side of the future, especially in young subjects, in whom the dura mater adheres more strongly than in adults; because there cannot be a free communication between the one side and the other, on account of the attachment of that membrane to the future.

After the elevation of the depressed pieces, or the removal of those which are quite loose, the extraction of extraneous bodies, and the evacuation of extravasated fluids, &c. the sore is to be dressed in the lightest and easiest manner; all that is necessary being to apply a pledget of fine scraped lint, covered with simple ointment, to that part of the dura mater which is laid bare by the trepan, or otherwise; after which the edges of the scalp are to be brought together or nearly so, and another pledget laid along the whole course of the wound; a piece of fine soft linen is to be laid over all, and the dressings may be retained in their place by a common night-cap applied close to the head, and properly fixed.

The patient is to be placed in as easy a position in bed as possible, with his head and shoulders elevated a little more than ordinary. If the operation be attended with success, the patient will soon begin to show favourable symptoms; he will soon show signs of increasing sensibility, and the original bad symptoms will gradually disappear. After this he ought to be kept as quiet as possible; proper laxatives are to be administered, and such as may be least of a nauseating nature. His food ought to be simple and easy of digestion, and his drink of the most diluent kind. If he complain of the wound being uneasy, an emollient poultice should be immediately applied, and renewed three or four times in the twenty-four hours. By these means there will commonly be a free suppuration from the whole surface of the sore.

Every time the wound is dressed, the purulent matter ought to be wiped off from it with a fine warm sponge; and if any degree of sloughiness take place on the dura mater or parts adjacent, it will then be completely separated. Granulations will begin to form, which will continue to increase till the whole arise to a level with the surface of the cranium. The edges of the sore are now to be dressed with cerate straps, and the rest of it covered with fine soft lint, kept gently pressed on by the night-cap properly tied. In this way the cure will go on favourably; luxuriance of granulations will commonly be prevented; the parts will cicatrize kindly; and as all the skin has been preserved in making the first incision, the cicatrix will be but little observed.

But things do not always proceed in this favourable manner. Sometimes in a few hours after the operation the patient is seized with a kind of restlessness, tossing his arms, and endeavouring to move himself in bed, while the symptoms of a compressed brain remain nearly the same as formerly. In this case, especially if the pulse be quick and strong, the patient ought to be bled freely, as there will be reason to suspect some tendency to inflammation in the brain. Sometimes, though the trepan has been properly applied, the symptoms are not relieved, on account of extravasated fluids collected internally under the dura mater, or between the pia mater and brain, or in the cavity of the ventricles. The danger in these cases will be in proportion to the depth of the collection. Particular attention therefore ought always to be paid to the state of the dura mater after the perforation has been made. If blood be collected below the dura mater, this membrane will be found tense, dark coloured, elastic, and even livid; in which case, an opening becomes absolutely necessary to discharge the extravasated

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of the pa-
tient after
the opera-
tion.

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and Depres-
sion of the
Cranium,
&c.

valated fluid. Gentle scratches are to be made with a scalpel, till a probe (fig. 27), or directory (fig. 28.), can be introduced; upon which the membrane is to be sufficiently divided in a longitudinal, and sometimes even in a crucial direction, till an outlet to the fluid be given.

After the dura mater has been cut in this manner, there is some danger of the brain protruding at the opening; but the danger from this is not equal to the bad effects arising from effused fluids compressing the brain.

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Of fungi.

A troublesome and an alarming appearance now and then follows the operation of the trepan; namely, the excrescences called *fungi*, formerly supposed to grow immediately from the surface of the brain, but which, in general, originate from the surface of the dura mater or cut edge of the bone granulating too luxuriantly.

It often happens that they possess little sensibility; and then the best method to prevent their rising to any great height is to touch them frequently with lunar caustic: but some cases occur where their sensibility is so great that they cannot be touched, unless they hang by a small neck; and then a ligature may be put round them, and tightened from time to time till they drop off, which will commonly be in the course of a few days. It seldom happens, however, that there is any occasion for applying such means for the removal of these tumors, for they generally fall off as the perforations of the bone fill up.

If they do not, as the connection between them and the brain will be then in a great measure intercepted, they may be with more safety removed, either by excision, by caustic, or by ligature.

The cure being thus far completed, only a small cicatrix will remain, and in general the parts will be nearly as firm as at first: but when much of the integuments have been separated or destroyed, as they are never regenerated, the bone will be left covered only by a thin cuticle, with some small quantity of cellular substance. When this is the case, the person ought to wear a piece of lead or tin, properly fitted and lined with flannel, to protect it from the cold and other external injuries.

This is the method now commonly practised in cases of compression; but it frequently happens, that instead of compression, such a degree of concussion takes place that no assistance from the trepan can be attended with any advantage; for the effects of concussion are totally different from those of compression, and therefore to be removed in a different manner.

SECT. II. *Of Concussion of the Brain.*

By concussion of the brain is meant such an injury, from external violence, as either obstructs or destroys its functions, without leaving behind it such marks as to allow its nature to be ascertained by dissection.

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Symptoms
of concus-
sion of the
brain.

Most of the symptoms attending compression of the brain occur also in concussion; but in a compressed state of the brain they are more permanent. There is no discharge of blood from the eyes, nose, or ears, which frequently happens in compression; and instead of that apoplectic stertor in breathing which accompanies compression, the patient seems to be in a sound and natural sleep. The pulse is irregular and slow in compression, and grows stronger and fuller by blood-letting; but in concussion it is weaker, being soft and equal, and sinks by blood-letting. There are besides convulsions in compressions, which are not observed in a state of concussion. The symptoms arising from concussion come on immediately after the injury is received. In the violent degrees of these the patient remains quite insensible; the pupils are much dilated, and do not contract though the eyes be exposed to the strongest light.

In more violent symptoms, especially when the patient

is rendered insensible, it is extremely difficult to distinguish between concussion and depression; for symptoms which have been supposed to arise entirely from concussion have, after death, been found to be owing to extravasation or undiscovered fracture; and extravasation has been blamed, when, on dissection, not the least morbid appearance could be discovered.

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Treatment.

In concussion the pulse will frequently sink and become feeble, even after the discharge of eight or ten ounces of blood: In doubtful cases, therefore, blood-letting should be practised with great caution. If the pulse become fuller and stronger after discharging a moderate quantity, if the blood appear fizy, and especially if the patient become more sensible, it may be concluded that the symptoms depend upon extravasation, depression of the skull, or some degree of inflammation; and as long as advantage seems to be derived from blood-letting, we may repeat it: but if, upon drawing a few ounces of blood, the pulse becomes feeble, and especially if along with this the patient become more weakly, we should immediately desist from any farther evacuation of blood; and in place of it we ought to give such remedies as may support and strengthen the patient: cordials ought to be given internally, and stimulants applied externally. Warm wine should be given in proportion to the degree of debility induced; the patient, who is apt, in this case, to become cold, should be kept warm by proper coverings; a blister ought to be put to all that part of the head in which the skin has not been injured; sinapis should be applied to the feet; gentle laxatives are useful, and should be regularly given, so as to keep the body open. If the patient cannot swallow wine in sufficient quantity, volatile alkali, ardent spirits, and other cordials of a stimulating kind, should be given. In concussions of the brain, Mr Bromfield has recommended the use of opiates, and several other practitioners agree with him; though some consider it as hurtful in the early stages of the disorder, and are of opinion that even wine and other cordials ought to be given with some degree of caution. Issues, or the frequent repetition of blisters to the different parts of the head and neck, by which an almost constant stimulus is preserved, are much recommended. When patients are recovering from accidents of this kind, a liberal use of bark, steel, and mineral waters, &c. have sometimes been of service. When the stomach is loaded, gentle vomits become necessary; and white vitriol is reckoned the best in such cases. When much languor, inactivity, and loss of memory continue, electricity long applied has been attended with advantage. This remedy, however, would be hurtful where any symptoms of compression or inflammation of the brain are present.

SECT. III. *Of Inflammation of the Membranes of the Brain, or of the Brain itself, from external Violence.*

INFLAMMATION of the brain and of its membranes is attended with symptoms which occur in inflammations affecting other parts of the body, and from similar causes, and likewise with symptoms peculiar to the brain itself. This disorder differs essentially from concussion in its not appearing immediately; seldom till several days after the accident, and sometimes not till two, three, or more weeks, or even as many months, have elapsed; when the patient begins to feel an universal uneasiness over his head, attended with listlessness, some degree of pain in the part upon which the injury was inflicted, though of this there was perhaps no previous sensation. These symptoms gradually increase; the patient appears dull and stupid; there is now a sensation of fulness, as if the brain were girt or compressed; he complains of giddiness and of nausea, which sometimes terminate in vomiting; he is hot, and extremely uneasy; his sleep

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of inflam-
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the brain
and its
membranes.

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tion of the
Brain, &c.

Inflamma-
tion of the
Brain, &c.

sleep is much disturbed, neither natural sleep nor that procured by opiates affording him relief; the pulse is hard and quick; the face is flushed; the eyes inflamed, and unable to bear an exposure to much light. Sometimes, where a wound of the head accompanies these symptoms, its edges become hard and swelled, and an erysipelatous inflammation spreads quickly over the whole head, and especially towards the forehead and eyelids, which frequently swell to such a degree as to shut up the eyes entirely. This swelling is soft and painful to the touch; it receives the impression of the finger, and frequently originates merely from the external wound; on which account the attending symptoms are commonly easily removed by the means best suited to erysipelas of the parts. In a few instances, however, this symptom is likewise connected with, and seems to originate from, some affection of the dura mater. Its tendency is then of the most dangerous kind, and therefore requires the greatest attention. Soon after these symptoms become formidable, the part which received the blow begins to put on a diseased appearance. If the bone has been exposed by the accident, it now loses its natural complexion, becomes pale, white, and dry, either over its whole surface or in particular spots: but when the bone has not been denuded, nor the softer parts divided, but merely contused, they now swell, become puffy, and painful to the touch; and when the head is shaved, the skin over the part affected is redder than the rest of the scalp; and if the swelled part be laid open, the pericranium will probably be found to be detached from the skull, and a little bloody fetid ichor will be observed between this membrane and the bone, which will be found discoloured in nearly the same manner as if it had been laid bare from the beginning.

By the application of proper remedies these symptoms are frequently entirely removed; but when neglected, or when they do not yield to the means employed, they constantly become worse. Delirium ensues; the patient becomes extremely hot; and is at times seized with slight shiverings, which continue to increase and are attended with some degree of coma or stupor. The former symptoms now in a great measure disappear; palsy of one side is soon followed by deep coma; the pupils are dilated; the urine and fæces are passed involuntarily; subsultus tendinum and other convulsions ensue; and death certainly follows, if the patient be not speedily relieved.

Of the above symptoms, the first set point out the inflammatory, the other the suppurative, stage of the disease. The remedies which are useful in the one are highly improper in the other. During the inflammatory stage, blood-letting is the principal remedy; but this is improper after the suppurative symptoms appear, for then the trepan is the only thing that can give relief.

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Method of
cure.

The indications of cure are; 1. To employ the most effectual means for preventing inflammation. 2. To endeavour to procure the resolution of inflammation by general and topical remedies. 3. When the inflammation cannot be removed by resolution, and when suppuration has taken place, to give a free vent to the matter. 4. If the affected parts be attacked with gangrene, to endeavour to remove it and obviate its effects.

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Blood-let-
ting proper
at first,

To answer the first indication, when the contusion is considerable, blood-letting, both general and topical, ought to be employed, and to a considerable extent; the bowels ought to be kept open by the use of laxatives; a watery solution of saccharum saturni should be applied to the part affected, and a low diet, with a total abstinence from exercise, ought to be enjoined: but if these means fail, or, as frequently happens, the practitioner has not been called in soon enough for their proper application, and if inflamma-

tion have actually commenced, the second indication ought then to be attended to. For this purpose, blood-letting, not from the feet according to the advice of old practitioners, but as near as possible to the part affected, is to be performed, by leeching, cupping, or scarifying with a lancet or scalpel.

When, instead of this, general blood-letting is thought more advisable, it is commonly reckoned best to open the external jugular vein, or the temporal artery; and the rule, with regard to the quantity to be evacuated, ought to be, to draw blood as long as the pulse continues firm; so that, in violent cases, taking away from 20 to 25 ounces at once will be found to answer the purpose better than to extract even a larger quantity, but at different intervals. A few hours afterwards, if the symptoms continue violent, it may be proper to discharge an additional quantity; but this must depend upon the strength of the patient and the fullness of the pulse.

Along with the liberal use of blood-letting, brisk purgatives should be given. The bowels should not merely be kept open; but in order to receive full advantage from the practice, a smart purging should be kept up by repeated doses of calomel, jalap, or some other neutral salt. Where the patient cannot swallow in sufficient quantity, stimulating injections should be frequently exhibited.

A moist state of the skin is useful in every case of inflammation, and ought therefore to be here particularly attended to. In general a mild perspiration may be induced by applying warm fomentations to the feet and legs, and by laying the patient in blankets instead of linen. But when these means are insufficient, diaphoretics or even sudorifics may be given.

When much pain or restlessness takes place, opiates should be administered freely, which are now found to be attended with real advantage.

With respect to the external treatment of this disorder, attention should be paid to those means which may most readily induce a free discharge of purulent matter from the seat of the injury. With this view, if the original accident be attended with a wound or division of the integuments, as the lips of the sore are commonly observed to be hard, painful, and dry, it should be covered with pledgets spread with an emollient ointment, and warm emollient poultices laid over the whole; by which means, and especially by a frequent renewal of the poultices, a free discharge of matter will commonly be induced, and the bad symptoms will generally be much mitigated, or entirely removed.

In cases unattended with a division of the integuments, as soon as it is suspected that bad symptoms may supervene, the tumor should be divided down to the pericranium; and if that membrane be found separated from the bone, it ought likewise to be divided; and by inducing a suppuration in the way already mentioned, the inflammatory symptoms will probably be removed. As matter formed here is commonly of an acrid nature, and therefore apt to affect the bone, and by communication of vessels the membranes under it, instead of wasting time till fluctuation be distinctly perceived, a free incision should be made as soon as a tumor is observable. But this would be extremely improper in the treatment of tumors which immediately succeed to external injuries; for it often happens that such tumors disappear spontaneously, or by the use of astringent applications. It is only when a tumor attended with pain appears at a distant period upon the spot where the injury was received, that it ought to be opened as soon as perceived.

The next part of the practice regards the remedies to be used

Inflamma-
tion of the
Brain, &c.

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Treatment
when sup-
puration
has taken
place.

used when the disorder has either proceeded to suppuration, or when, on a removal of a portion of the cranium, the dura mater is observed to be sloughy with a tendency to gangrene; and this includes the third and fourth indications of cure.

The suppurative state of the disease is known by the inflammatory symptoms, instead of yielding to the remedies already advised, increasing in violence; and being succeeded by coma, dilatation of the pupils, a slow and full pulse, involuntary discharge of feces and urine, palsy, and irregular convulsive motions, and especially when these symptoms are succeeded by fits of rigor and shivering.

The existence of matter within the cranium being ascertained, as no other remedy can be depended upon for removing it, the operation of the trepan should be immediately employed, and as many perforations ought to be made as may be sufficient for evacuating the matter. But if, after the skull is perforated, little or no matter appear between the bone and membranes; if the dura mater seem more tense than usual; this membrane is likewise to be opened, so as to give a free discharge to any matter which may be between the brain and its membranes.

When it is perceived that the dura mater has already become sloughy, with some tendency to gangrene, the greatest danger is to be dreaded. If mortification has commenced, there will be much reason to think that death will soon follow; but different instances have occurred of sloughs forming upon the dura mater, and of cures being made after these have separated. All that can be attempted is to keep the sores clean, to give a free discharge to the matter, to apply nothing but light easy dressings, and to give bark in as great quantities as the stomach can bear. If there be still some tendency to inflammation, the diet should be low and cooling, the patient should drink freely of whey or other diluent liquors, and the bowels should be kept moderately open: But if, on the contrary, the system be low and the pulse feeble, wine is the most effectual cordial.

SECT. IV. *Of Fissures, or simple Fractures of the Skull.*

THE term is here meant to imply a mere division of one or both the tables of the skull, with or without a wound of the integuments, not attended with depression. Fractures of this kind are not dangerous as far as affects the skull only, for it frequently happens that extensive fissures heal without producing bad symptoms. But as they are frequently attended with effusions of blood or serum upon the brain or its membranes, or as they may tend to excite inflammation in these, they require particular attention.

When effusions occur, symptoms of compression immediately follow. The remedies best suited to this disease must then be applied; and the trepan is alone to be depended upon. The fissures should be traced through their whole extent, and a perforation made on the most depending part of each of them. If this be unsuccessful, the operation should be repeated along the course of the fissures as long as symptoms of a compressed brain continue; and as the effused matter will commonly be found contiguous to the fissures, they ought to be included in each perforation.

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Methods of
distinguish-
ing fissures.

If the fissure be so large as to produce an obvious separation of the two sides of the bone, the nature of the case will be at once rendered evident; but where it is extremely small, there is difficulty in distinguishing it from the natural sutures, or from sutures surrounding small bones, which sometimes occur, and get the name of *ossa triquetra*. But this may be known by the firmer adhesion which always exists between the pericranium and sutures; whereas this membrane is always somewhat separated from that part of the bone where a fissure is formed. When the pericranium is

separated by the accident for a considerable way from the surface of the bone, various means have been contrived for discovering the nature of the case; as pouring ink upon the part suspected to be fractured, which in case of a fracture cannot be wiped entirely off; or making the patient hold a hair or piece of catgut between his teeth, while the other extremity of it is drawn tense, which, when struck, is said to produce a disagreeable sensation in the fractured part. But such tests are little to be depended on; ink will penetrate the sutures; and the others are ineffectual, unless the fracture be extensive, and the pieces considerably separated from each other. The oozing of the blood from a fissure is a better mark. The ascertaining of this point, however, appears not very material; for unless alarming symptoms are present, although there should be a fissure, no operation is necessary; and if such symptoms occur, the bone ought to be perforated whether there be a fissure or not.

When a fissure is not attended with symptoms of a compressed brain, the trepan ought not to be applied, especially as the operation itself tends in some degree to increase inflammation of the part. The fissure should be treated merely as a cause which may induce inflammation. The patient should be bled according to his strength; the bowels should be kept lax, and the sore treated with mild, easy dressing; and violent exertion should be avoided as long as there is any danger of inflammation occurring.

CHAP. XIII. *Diseases of the Eyes.*

SECT. I. *Of Wounds of the Eyelids and Eyeball.*

IN cases of superficial wounds of the eyelids, it will be sufficient to bring the edges of the wounds together and retain them in their place by slips of adhesive plaster: but when a wound is deep, particularly when the tarsus is divided, it will be necessary to employ either the interrupted or the twisted suture, care being taken that the sutures be not carried through the inner membrane of the eyelid, otherwise the eye would be irritated and inflamed. After such an operation, the motion of both eyelids should be prevented as much as possible, else no union of the divided parts can be obtained. After the sutures are finished, the eyelids should be closed and covered with a pledget of emollient ointment, and over this should be laid a compress of soft lint, and one of a similar nature ought likewise to cover the sound eye; then a napkin should be made to press equally on both eyes, and be properly fixed. Inflammation should be guarded against, or, if already present, it must be removed in the manner directed under the article *Ophthalmia*, (see *MEDICINE*.) The sutures may be removed in about three days from their introduction, when the parts will commonly be found reunited.

When a portion of the eyelids is so much destroyed, or perhaps so completely removed, as to prevent the remaining parts from being brought together, without obstructing the motion of the eye, the best method will be to treat them with light easy dressings, trusting to nature for supplying the deficiency.

If the cornea be wounded, it will commonly be attended with partial or total blindness. If any of the other parts of the ball be wounded, the danger will generally be in proportion to the extent of the wound. The principal attention ought to be directed to the prevention or removal of inflammation. When pain occurs, it ought to be removed by opiates; and with these a strict antiphlogistic course is to be enjoined.

When the wound is large, and the humours completely evacuated

Diseases of the Eyelids evacuated, blindness, with sinking of the eyeball, will almost always be the consequence; but in wounds of a small extent, by proper treatment, a cure may be made and the sight preserved.

SECT. II. *Of Diseases of the Eyelids.*

200 Tumors of the eyelids. THE eyelids are subject to be infested with tumors of different kinds, which frequently require the assistance of surgery. The first of these is the hordeolum or sty, which frequently grows on the edge of the eyelid, and is attended with heat, stiffness, and pain; and unless proper means be taken to prevent it, a suppuration is frequently the consequence. It may be considered as a common abscess seated in an obstructed sebaceous duct or gland. It may generally be removed by discutient applications. Should these prove ineffectual, it ought to be brought to suppurate by a small emollient poultice, when it will commonly heal of itself; but if it do not, it may be opened with the point of a lancet, that the matter may be discharged; and the part may be anointed afterwards with saturnine solution.

The eyelids are subject to encysted tumors, steatoma, warts, &c. which are to be treated like the same tumors when seated in other parts of the body; only in extirpating these tumors, should part of the eyelid be removed entirely, no dressings can be applied, as, however mild they may be, they would irritate and inflame the ball of the eye. All that can be done therefore, in such cases, is to lay the lips of the sore as nearly together as possible, and frequently to remove any matter that may form on it.

201 Inversion of the cilia or eyelashes. The eyelashes are sometimes so much inverted as to rub upon the eye and create much pain and inflammation. Various causes are assigned for this, such as the hairs themselves taking a wrong direction; inversion of the tarsus or cartilage of the eyelid; some cicatrix formed upon the skin of this part after wounds or abscesses; tumors pressing the hairs in upon the eye; and, finally, a relaxation of the external integuments.

The treatment of this disorder must depend much upon a knowledge of the cause. When it is owing to a derangement of the cilia themselves, if they have remained long in this state, it will be extremely difficult to make them recover their proper direction. They ought therefore to be pulled out by a pair of forceps, and the part washed with some astringent lotion; and if the new hairs appear to take a similar direction, which is very apt to happen, as soon as they are long enough they ought to be turned back upon the eyelid, and kept there for several days, or even weeks, by adhesive plaster. When the disease proceeds from a contraction of the orbicular muscles, the contracted part may be cut from the inner surface of the eyelid; in which place a cut commonly soon heals. If the cause proceed from a tumor or cicatrix, this must be removed before a cure can be expected; or if it be owing to relaxation of the skin, the parts ought to be bathed with some strong astringent. If this fail, the relaxed skin should be removed, and the part healed by the first intention. Sometimes the cilia of the upper eyelid are turned in on account of dropical swelling in that place. When this happens, the water is to be evacuated by a few punctures with a lancet; but when such means fail, and when the disease is quite local, if vision be disturbed, a sufficient part of the skin ought to be removed with a scalpel, and a cure made by adhesive plaster or the twisted suture.

202 The gaping eye, or turning out of the eyelids. When the gaping eye takes place to any great degree, it is attended not only with much deformity and uneasiness, from a large portion of the lining of the eyelid being turned outwards, but likewise from too much of the eye being exposed. The disorder may arise from an enlargement of

the eyeball, from dropical swelling, or from the cicatrix of an old wound or abscess: hence it is frequently produced by the small-pox, burns, or scrophula; but more frequently by a laxity of the part in old age.

When the disorder is induced by an enlargement of the ball of the eye, nothing but a removal of this swelling can be effectual. If from dropical swelling, when this is connected with general anasarca, the affection of the system must first be cured; but if it appear to be local, nothing answers so well as punctures. When it arises from a cicatrix, the skin should be divided, and the effects of inflammation guarded against. If it be owing to inflammation, the antiphlogistic course must be used; when it arises from old age, the eyes ought to be daily bathed with cold water, or some astringent and stimulant solution.

203 Concretion of the eyelids. Concretion of the eyelids sometimes arises from a high degree of ophthalmia; in which case the eyelids are not only connected by their edges to each other, but now and then grow to the surface of the eyeball. A cohesion is sometimes observed also in children at birth. When the adhesion is slight, it may in general be removed by the end of a blunt probe; but when it is considerable, a cure can only be effected by a cautious dissection. If the eyelids on one side be sound, they will serve as a guide to direct the incision. The tarsi are carefully to be divided from each other; after which, if there be no other adhesions, the eyelids may be readily opened: But if they adhere to the eye, the operator is gently to pull and separate the eyelids, while the patient is desired to move the eye in the opposite direction. When this is effected, nothing is further necessary than to drop a little oil upon the eye, and cover the eyelids with soft lint spread with some cooling emollient ointment. The oil and ointment are frequently to be repeated, and every precaution taken to prevent inflammation and irritation.

SECT. III. *Of Specks, Films, or Excrescences on the Eye.*

204 Of specks on the cornea. SPECKS are sometimes formed upon the white part of the eye, but more frequently upon the cornea. In the former case they are seldom attended with much inconvenience, but in the latter they are often the cause of partial or total blindness. They are almost universally the consequence of inflammation, and seldom go much deeper than the tunica adnata. Two very different states of the disorder occur; the one from an effusion immediately under the outer layer of the cornea, and in this case the cornea does not appear to be raised; the other takes place from one or more little ulcers, which breaking, leave as many opaque spots in the centre, which are more elevated than the rest of the cornea: and the inconvenience attending either situation must always be in proportion to their extent and degree of opacity, or their vicinity to the pupil. When vision is little affected by them, they need scarcely be considered as an object of surgery; but whenever vision is materially impaired, remedies become necessary, and these should be such as are best suited for removing inflammation, promoting absorption, and restoring tone to the vessels. For the means adapted for removing inflammation, see MEDICINE, n^o 175.

205 Treatment. Vessels running upon the surface of the eye into the speck are to be divided, and the eye frequently bathed with some refrigerant collyrium. By these means the simplest kind of specks, when recently formed, may generally be removed; but where they have been of long standing, their removal is attended with great difficulty. Where the speck is owing to an effusion of fluids between the layers of the cornea, and where it is not attended with any prominence, local applications are of little advantage, as it

Specks, &c.
on the Eye.

is impossible to remove the effused matter without injuring the cornea; but considerable service is derived from the use of such remedies as are most effectual for promoting absorption; and with this view a gentle, long continued course of mercury, brisk purgatives occasionally, and issues in the neck, are found to be the most effectual remedies.

In the management of specks which are prominent upon the cornea, and where inflammation is removed and the opacity is considerable, if the cornea beneath be found, the removal of the diseased part will leave it transparent and fit for vision. The remedies proper for this purpose are escharotics or the knife. The former are applied in the form of a powder, an ointment, or a wash; and these ought to be very finely prepared, otherwise they will be in danger of irritating and inflaming the eye; and they ought merely to be of such strength as the eye can easily bear.

The applications should be long persisted in and frequently repeated; and to make them still more useful, some of the powders or ointments may be applied evening and morning, and the solution two or three times through the course of the day. To the remedies already mentioned caustic is sometimes preferred. With this the centre of the speck is to be frequently touched, till the patient complain of considerable pain, when pure water is to be applied by a pencil, or by dipping the eye in water, with the eyelids open, till the pain occasioned by the application of the caustic be removed. The eye is then to be covered with compresses moistened in some solution, and this frequently repeated. The caustic to be repeated every second or third day, unless prevented by inflammation. When the surgeon chooses to employ the knife, which frequently may be more effectual, the eye is to be fixed by a speculum (fig. 29.), or levator (fig. 30); the tumor is then to be cautiously separated by means of a small knife, and every attention paid to pre-inflammation. These are the methods most likely to be of service; and when properly managed, they will frequently remove specks, which otherwise would entirely deprive the patient of the use of the eye; though it is to be regretted that cases frequently occur which baffle art.

206
Of the ex-
crecence
called *ptery-*
gium.

A membranous excrescence, called *pterygium*, is frequently found upon the white part of the eye, which often spreads over the cornea so as entirely to destroy vision. It is sometimes owing to external injuries; at other times it arises from a general disease of the system, as lues venerea or scrophula; but inflammation is always the more immediate cause.

207
Method of
removing
excrecences.

By a proper application of the remedies above mentioned affections of this kind may generally be prevented from becoming formidable; but when the reverse takes place, and excrescences begin to spread over the cornea, other means must be used. When the diseased part is only slightly attached, it may be freely removed by a cut of the knife; but when this cannot be done without difficulty, it is better to destroy the vessels by the extension of which this substance is chiefly formed. The manner of performing the operation in general is this: The patient being properly seated, the eyelids opened, and the eye secured, the operator, with a small knife, makes a scarification through the whole thickness of the excrescence, entirely round, and at a little distance from the circumference, by which the source of nourishment will be cut off; and, after the bleeding is abated, one or two incisions more may be made, in a similar manner, within the former. Some practitioners raise the excrescence with a needle and ligature before the incision is made; and, in some cases, this may be done with advantage, though not in others.

After the bleeding is over, the part is to be bathed two or three times a-day with a weak saturnine solution; and the operation may be repeated occasionally till the excres-

cence is removed. In this way the operation commonly proves effectual; but instances sometimes occur where, instead of being useful, it increases the disease. Whenever this happens, a palliative course is the only thing to be tried; and although it will not remove the disorder, it may commonly prevent the excrescence from acquiring any additional size. With this intention it ought to be frequently bathed with the solution last mentioned, and afterwards covered with a cooling ointment. When the disorder cannot even be palliated, when vision is destroyed, and particularly when the pain attending it is severe, there is reason to suspect cancer. In this case the eye ought to be extirpated, otherwise deeper parts may suffer, and the life of the patient be endangered. The method of performing this operation will be afterwards pointed out.

Abcesses
in the
Globe of
the Eye.

SECT. IV. Of Abcesses in the Globe of the Eye.

THOUGH inflammation of the eye generally terminates by resolution, instances sometimes occur in which an abscess ensues. This is owing either to improper treatment, or a bad habit of body which counteracts all remedies. The greatest danger attending these complaints is when they are situated on the cornea, as the cicatrix left by them may destroy vision. When deep seated, a purulent matter is sometimes apt to be found in some of the chambers of the eye, the ball becomes enlarged, the humours are disturbed, and neither the iris, pupil, nor lens can be distinguished. In some rare cases again, after these appearances have continued some time, the cornea bursts, part or whole of the humours are evacuated, and the iris protrudes in a thickened distended state. This has now the appearance of an excrescence, which is called *staphyloma* from a kind of resemblance to a grape. But under this term some authors include all collections like those above described. In most instances the cornea protrudes, but in others the tunica sclerotica or opaque part is affected with partial swellings or protrusions.

While the disease is forming, besides the loss of sight, the patient commonly feels great distress in the eye and head, accompanied by symptoms of fever. When no other distress is experienced than the loss of sight, the swelling is but small, and contains chiefly a watery fluid. In the treatment, as vision is seldom preserved, the principal thing is to abate the pain and remove deformity. There is another kind of abscess in the eye, termed *hypopyon*, where the matter is lodged in the substance of the coats. It is sometimes produced by external injuries, but more frequently from pustules of small-pox. If this termination cannot be prevented by the remedies mentioned in the article MEDICINE, n^o 175, the matter must be evacuated by an incision into the eye, not regarding the humours, as vision previous to this time is entirely destroyed. The proper part is the cornea or the most prominent part of the tumor.

A variety of this disorder sometimes, though rarely, happens, where the humours are absorbed; but still the same external appearances are observed. In this case the tumor is formed by a thickening of the coats, especially the iris. The only means of relief is extirpation of the prominent part by the use of the knife. After the contents of the eye have been discharged, the parts are to be covered with a compress moistened with a saturnine solution, and the antiphlogistic course followed, till a cure is perfected, or at least inflammation removed. If the ulcers discharge a thin acrid matter, they may be washed two or three times a day with a solution of corrosive sublimate, or of white vitriol, &c. Fungous excrescences, sometimes considered as a cancer of the eye, are apt to form in both these diseases after the matter is evacuated; but they may be prevented from in-

creasing

Dropical
Swellings
of the Eye.

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Ulcers of
the eye.

creasing to a considerable size by burnt alum finely powdered, or by touching them occasionally with lunar caustic.

Ulcers on the eye may arise from the same causes which produce ulcers on other parts of the body, as wounds, burns, &c; or they may arise from a general affection of the constitution, as lues or scrophula; but they are more immediately produced by inflammation. In the treatment therefore of such diseases, blood-letting, blistering, laxative and cooling applications, as already described in the case of ophthalmia, are to be employed. When the inflammatory state is removed, their management must be almost the same with that for similar affections in other parts of the body. When the disorder arises from an affection of the system, the primary disease must be attended to before a cure can be performed. With respect to the sores themselves, if acrid matter be discharged, we must have recourse to detergent ointments and washes before a cicatrix can be formed. When these have not the desired effect, and when the sore becomes soft and higher than the rest of the eye, astringent applications are most efficacious. If excrescences be present, these are to be removed by escharotics, or by the knife. In some rare instances excrescences of a fungous nature are found to be connected with the interior parts of the eye, and become so prominent as even to rest upon the cheek. When such occur, nothing but the removal of the eye itself can effect a cure.

SECT. V. *Of Dropical Swellings of the Eye.*

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Symptoms
of dropy
of the eye.

THE eye is sometimes enlarged by an accumulation of the aqueous humour. The symptoms are, a sense of fullness in the eyeball; by degrees the motions of the eyelids become impeded; vision gradually becomes more and more imperfect, till at last the patient can only distinguish light from darkness. As the disease increases, the ball of the eye becomes greatly enlarged, and at this time the cornea begins to protrude; when, if a puncture be not made, the eye bursts and empties itself. This disease is apt to be confounded with staphyloma. But in the dropical swelling the patient is always sensible to the effects of light, and the pupil is observed to contract, which does not happen in staphyloma. In the early stages of this disease vision may be preserved by puncturing the under edge of the cornea, and allowing the aqueous humour to pass out by the anterior chamber; or by puncturing the tunica sclerotica a little behind the iris, by which the fluid will pass out by the posterior chamber. The puncture may be made either with a lancet, pointed knife, or with a very small flat trocar. The eye ought afterwards to be dressed with a compress made moist with a saturnine solution, guarding against excessive inflammation. When the use of the eye is somewhat recovered, tone may be restored to the parts, and a return of the disease as much as possible prevented, by frequently bathing the eye in astringent lotions; but where the cornea is destroyed, the sight cannot be restored: We can then only diminish the size of the eye, and render it somewhat more comfortable to the patient.

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Treatment

211
Blood effu-
sed into the
eye.

Blood may be effused into the chambers of the eye from various causes, as in putrid diseases, or in consequence of inflammation, but most frequently from a rupture of the blood-vessels induced by external injury. In whatever way it gets into the eye, it mixes with the aqueous humour, and renders it opaque. It is sometimes taken up by the absorbents; when it is otherwise, it ought to be discharged by a puncture.

A few instances have occurred where the blood has fallen to the under side of the eye, and remained there without mixing with the aqueous humour. In such a situation it ought to be allowed to remain.

When a puncture is necessary, it is to be made in the same manner as in cases of dropy of the eye; only the opening may require to be somewhat larger, otherwise the blood may not pass readily out. After the operation, nothing is necessary but to apply a compress of soft lint, moistened with a weak saturnine solution.

Protrusion
of the Eye-
ball beyond
its Socket.

SECT. VI. *Of the Protrusion of the Eyeball beyond its Socket.*

THE eye may protrude in consequence of external violence, or from tumors forming behind it, or on account of some of the ulcers, excrescences, or dropical swellings, already mentioned. When the eye is forced out of its socket by external violence, if the eyeball be not entirely separated from the neighbouring parts, it ought to be freed from any extraneous matter which may adhere to it, and immediately replaced; and if the optic nerve be not quite divided, the use of the eye may be recovered. With a view to prevent or moderate inflammation, every part of the antiphlogistic regimen ought to be strictly adhered to. If the protrusion is occasioned by a tumor, the cure must depend upon the removal of this; and if the disease has advanced so far that the bones are become carious, they must likewise be separated. But more frequently, instead of the bones becoming carious, they assume a gelatinous or rather cartilaginous nature. In such a situation an operation could be of little advantage. The best method to prevent the bones from being so affected is an early performance of the operation.

A few instances have happened of the eye being pushed from its socket by an enlargement of the lachrymal gland. When this occurs, if the enlargement be considerable, the structure of the eye will most probably be so much injured that vision will be destroyed; but instances have occurred of this gland, in the enlarged state, having been removed without any injury being done to the eye.

SECT. VII. *Of Cancer of the Eye, and Extirpation of the Eyeball.*

SCIRRHUS and cancer may arise from repeated inflammations of the eye, or from staphyloma, or some of the other diseases which frequently attack this organ. The symptoms are, an enlargement, hardness, and protrusion of the ball, with a red, fungous appearance, sometimes discharging thick, yellow matter, but more frequently a thin acrid ichor. At first there is only a sensation of heat in the tumor; but this gradually increasing, changes at last into darting pains, which likewise shoot through to the opposite side of the head. In this situation blood-letting, opiates, and emollient applications, may alleviate the pain. A hemlock poultice applied to the eye, and a wash of lime-water, with a little opium dissolved in it, and applied every time the poultice is renewed, gives some relief; but altho' the pain be moderated by these means, it does not prevent the disease from spreading, nor can any thing else but extirpation produce a radical cure.

After the disease is discovered to be cancerous, the operation should be performed without delay, to prevent the parts in the neighbourhood, as well as the constitution at large, from suffering. In performing the operation, the patient should be placed in a proper light, and the head supported by an assistant. If the eyelids are diseased, they must be separated along with the tumor; but where they are sound, they ought to be carefully preserved; and for this purpose they may be kept out of the way by two levers held by assistants. When the eyeball protrudes considerably, the operator may lay hold of it with his fingers; but if this be impracticable, a broad ligature should be introduced through the centre of it, that it may be the more readily

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Symptoms
of cancer of
the eye.

213
Method of
extirpating
the eye.

Cataract. readily removed from the orbit. Sometimes it will be necessary to enlarge the opening of the eyelids, by cutting the external angle to allow the eyeball to be more readily removed. The whole of the diseased parts are now to be separated by a knife bent so as to correspond with the sides of the orbit, guarding at the same time against wounding the periorbital or the bones of the orbit, which are commonly extremely thin. The eye being in this manner extirpated, the hemorrhagy from the ocular arteries is to be suppressed by means of agaric, or by a bit of sponge; then over this is to be laid soft lint, with a napkin to cover the whole. After suppuration takes place, the dressings are to be removed, when a little lint, applied with an emollient pledget over it, will be sufficient as long as any matter is discharged. After the wound is healed, the deformity may be in some measure obviated by wearing an artificial eye; though it is chiefly in cases where part of the humours of the eye have been evacuated that this can be used with much propriety; for when the orbit is empty the artificial eye sinks too far into it.

SECT. VIII. *Of the Cataract.*

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Symptoms
of cataract.

THE ancients, and some of the modern writers, had a confused idea of the seat of the cataract; different authors placing it in different parts of the eye. It consists of an affection of the crystalline lens or of its capsule, by which the rays of light are prevented from falling upon the retina; and is therefore the same disease with the glaucoma of the ancients. It commonly begins with a dimness of sight; and this generally continues a considerable time before any opacity can be observed in the lens. As the disease advances the opacity becomes sensible, and the patient imagines there are particles of dust or motes upon the eye, or in the air. This opacity gradually increases till the person either becomes entirely blind, or can merely distinguish light from darkness. The disease commonly comes on rapidly, though sometimes its progress is slow and gradual. The opacity of the lens is found to be nearly in proportion to the degree of blindness the patient is affected with; it gradually changes from a state of transparency to a perfectly white, or light grey colour. In some very rare instances a black cataract is found. Sometimes the disease is confined to a particular spot of the lens, but generally the whole is affected. The consistence also varies, being at one time hard, at another entirely dissolved. When the eye is otherwise sound, the pupil moves according to the degree of light in which it is placed. This disease is seldom attended with pain; sometimes, however, every exposure to light creates uneasiness, owing probably to inflammation in the bottom of the eye. The real cause of cataract is not yet well understood. Numbers of authors consider it as proceeding from a preternatural contraction of the vessels of the lens, arising sometimes from external violence, though more commonly from some internal and occult cause. The disease is distinguished from the gutta serena, by the pupils in the latter being never affected with light, and from no opacity being observed in the lens. It is distinguished from hypopyon, staphyloma, or any other disease in the fore part of the eye, by the evident marks which these affections produce, as well as by the pain attending their beginning. But it is difficult to determine when the opacity is in the lens or in its capsule. The lens is generally affected; when the capsule is the seat of the disease, it is termed the membranous cataract.

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Methods of
treatment.

With respect to the treatment: If the disease be in the incipient state, mercury, particularly calomel in small doses, has been attended with some advantage. When any degree of inflammation is present, blood-letting and cooling regimen

will sometimes be necessary. Electricity, extract. hyoscyami, flammula Jovis, &c. have likewise been extolled; but after these or other remedies have failed, the cure must depend upon a surgical operation. For this purpose two methods are in general use. The first of these, and which was practised for a long time before the other, is called *couching*. It is done with a view to allow the rays of light to fall upon the retina; and it consists in removing the lens from its capsule, and lodging it in some part of the vitreous humour, where it may be entirely off the axis of the eye, and where it is supposed, in course of time, to dissolve.

The other method is termed *extraction*, where, after an incision has been made in the cornea, the lens is pushed through the pupil, and then entirely removed from the eye. Each of these methods has been much practised, and it is still a matter of doubt to which we ought to give the preference. The next circumstance deserving attention is the time at which the operation for couching or extracting can with most propriety be performed. Formerly it was thought necessary to wait till the lens had a certain degree of consistence, or was become ripe; but no certain marks of fluidity or firmness have been yet discovered; neither indeed is there any necessity for attending particularly to it, as the operation may be practised in every period of the disease, providing the retina be sound, the iris have the power of contracting, and the cornea be transparent. The proper time for the operation is when the opacity of the lens is so considerable as to prevent the patient from following his ordinary occupation. When this is not the case, or when the patient has the use of one eye, it ought not to be performed, as it is always attended with some degree of danger.

When the operation is to be performed, the following is the method of doing it: And first, *of couching the cataract*. To guard as much as possible against the effects of inflammation, the patient should be confined, for several days previous to the operation, to a low regimen; and two or three doses of some cooling laxative should be given at proper intervals. After this he is to be seated with his face towards the light; but sunshine ought to be avoided. Some, however, prefer a side-light both on account of the operator and patient. One assistant is to support the head, while others secure the arms. The operator is either to be seated with his elbow resting upon a table; or, which is preferred by some, he ought to stand, resting his arm upon the side of the patient. The eye being fixed by the speculum (fig. 29.), or in such a manner as to allow the whole of the cornea and a small portion of the sclerotic coat to protrude, a couching needle (fig. 31.) is to be held in the right hand, in the manner of a writing pen, if the left eye be the subject of operation; the ring and little fingers are to be supported upon the cheek or temple of the patient: The needle is to be entered in an horizontal direction through the sclerotic coat, a little below the axis of the eye, and about one fourth of a line behind the edge of the cornea, so as to get entirely behind the iris. If the needle be of the flat form, the flat side ought to be opposed to the iris, to prevent that substance from being wounded. The point of the needle is to be carried forwards till it be discovered behind the pupil. The operator is now commonly directed to push the point into the lens, and depress it at once to the bottom of the eye; but in this way the lens either bursts through the capsule at an improper place, or it carries the capsule with it, tearing it from the parts to which it is connected. Instead of this, the needle ought first to be pushed into the lens near its under edge, as Dr Taylor advises, and then carried some way down into the vitreous humour, so as to clear the way for the lens. It is then to be drawn a little back, and carried to the upper part

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Method of
couching
the cata-
ract.

Cataract. part of the capsule, when, by pressing upon it, the lens, if solid, is to be pushed down by one, or, if fluid, by several movements, to the bottom of the vitreous humour. It should then be pushed downwards and outwards, as Mr Bell directs, so as to leave it in the under and outer side of the eye; where, in case it should rise, the passage of the light would be little obstructed. The needle is then to be withdrawn, the speculum removed, and the eyelids closed; and a compress soaked in a saturnine solution is to be applied over them. Mr Pellier's method is to cover each eye with a linen bag half filled with fine wool, applied dry and fixed to a circular bandage of linen passed round the forehead: the whole is retained by a triangular napkin. The patient is then to be laid in bed, upon his back, with his head very little raised; and to be kept in this situation for about a week in a dark room. Unless he be of a weakly habit, he ought to be bled at the neck, or leeches at the temple, a few hours after the operation. He should be kept upon low diet, and get small doses of opiates frequently repeated. His belly should be kept moderately open by gentle purgatives. The dressings should not be removed till inflammation is at least so far gone that no danger will arise from uncovering the eye, which may generally be about the eighth or tenth day. Sometimes the patient perceives light immediately on the dressings being removed, but more frequently not till some time after.

Upon removing the dressings, if the cataract has again got back to the axis of the eye, a repetition of the operation may become necessary. Some time, however, after the inflammatory symptoms are gone, should be allowed to elapse before any other operation is again attempted; for the cataract frequently dissolves, providing the aqueous humour get free access to it. Mr Pott sometimes, when he found the cataract to be of the mixed kind, did not attempt depression, but contented himself with a free laceration of the capsule; in which cases the lens hardly ever failed of dissolving so entirely as not to leave the smallest vestige of a cataract. When the operation is to be performed upon the right eye, the straight needle must either be used by the left hand, or the operator must place himself behind the patient. A needle (fig. 32.) has been contrived, however, with a large curve, by which the operation may be readily performed with the right hand, while the surgeon is placed before the patient; only the needle is entered towards the inner, instead of the outer, angle of the eye.

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Method of extracting the cataract. The first hint of extracting the lens seems to have been suggested by Mr Petit, who proposed to open the cornea and extract the lens when it was forced into the anterior chamber of the eye either by external violence or accidentally in couching. At first it was considered as a dangerous operation, and was seldom practised till about the year 1737, when Mr Daviel proposed and practised extraction in preference to couching. The operation is now performed in the following manner: The patient and operator being placed, and the eye fixed in the same manner as for couching, the speculum, when the operation is to be done upon the left eye, is to be held in the left hand of the operator. It is necessary to make as much pressure as will secure without hurting the eye. Neither ought the cornea to be pressed too near the iris, lest the latter be wounded. The operator now takes the knife (fig. 33.), and holds it in the same way as he does the needle for couching; he then enters the point of it with the edge undermost into the cornea about the distance of half a line from its connection with the sclerotic coat, and as high as the centre of the pupil; he is then to pass it across the pupil to the inner angle in an horizontal direction, keeping the edge a little outwards to prevent the iris from being cut; the point is

then to be pushed through opposite to where it entered; the under half of the cornea is next to be cut, and at the same distance from the sclerotics with the parts at which the point of the knife went into and came out from the eye.

In cutting the under half of the cornea the pressure of the speculum upon the eye should be gradually lessened; for if the eye be too much compressed, the aqueous humour, with the cataract and part of the vitreous humour, are apt to be forced suddenly out immediately after the incision is made. The operator then takes a flat probe, and raises the flap made in the cornea, while he passes the same instrument, or another probe (fig. 34.), rough at the extremity, cautiously through the pupil, to scratch an opening in the capsule of the lens. This being done, the eye should be shaded till the lens be extracted, or the eyelids are to be shut to allow the pupil to be dilated as much as possible; and while in this situation, if a gentle pressure be made upon the eyeball at either the upper or under edge of the orbit, the cataract will pass through the pupil more readily than it would do when the eyelids are open.

If the lens cannot be easily pushed through the opening of the cornea, no violent force should be used, for this would tend much to increase the inflammation. The opening should be enlarged, so as to allow the lens to pass out more freely. When the cataract does not come out entire, or when it is found to adhere to the contiguous parts, the end of a small flat probe, or a scoop (fig. 35.), is to be introduced, to remove any detached pieces or adhesions that may be present. The iris sometimes either projects too much into the anterior chamber, or is pushed out through the opening of the cornea. When this happens, it is to be returned to its natural situation by means of the probe already mentioned. Sometimes the opacity is not in the body of the lens, but entirely in the capsule which contains it. The extraction of the lens alone would here answer no useful purpose. Some practitioners attempt to extract, first the lens, and then the capsule by forceps; others, the lens and capsule entire. Those who have had much practice in this branch of surgery, as Pellier, say they find such a method practicable; but others think it better to trust entirely to time and a cooling regimen for the cure, which, in some instances, has taken place. When the operation is to be performed on the right eye, the operator is either to use the left hand, to take his station behind the patient, or to employ a crooked knife (fig. 36.)

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Treatment after the operation. After the operation is finished, the eyelids are to be shut, and the same treatment observed as in couching. When the operation succeeds, the wound in the cornea is generally healed in little more than eight or ten days; but previous to this time, the eye ought not to be examined; and even then it should only be done in a dull light, otherwise it may suffer considerably from the irritation which a strong light might occasion. When the eye is to be examined, if the eyelids be found adhering together, they ought to be washed with some gentle astringent. With this the eye ought also to be frequently washed afterwards, by which it will gradually recover strength and sight. About the end of the third week the dressing may be entirely removed, and a piece of green silk put over the eyes as a shade; and if every thing has succeeded, the patient may generally go out after a month from the time at which the operation was performed.

It sometimes happens, that in extracting the lens a portion of the vitreous humour is evacuated. This does not in general prevent the success of the operation. The eye soon begins to fill again, and in the course of two or three weeks

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weeks it is for the most part as large as it was previous to the operation. Whether this be owing to a renewal of the vitreous humour, or merely an aqueous secretion, is not yet determined; though the latter circumstance is generally supposed.

CHAP. XIV. Of *Fistula Lachrymalis*.

By this disease is properly understood a sinuous ulcer of the lachrymal sac or duct with callous edges, though every obstruction of this passage is commonly called *fistula lachrymalis*.

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Symptoms
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The first and most simple state of the disease is that termed a *dropsy of the lachrymal sac*. The symptoms are, a tumor between the inner cornea of the eye and side of the nose. This disappears by pressure, the tears mixed with mucus passing partly into the nose, but chiefly back upon the eye and over the cheek.

This state of the disease is what the French have called the *hernia*, or *hydrops sacculi lachrymalis*. It is frequently met with in children who have been rickety, or are subject to glandular obstructions: and in this state it sometimes remains for several years, subject to little alterations, as the health or habit shall happen to vary, the sacculus being sometimes more, sometimes less full and troublesome; the contents which are pressed out are sometimes more, sometimes less cloudy; and now and then the disease is attended with a slight ophthalmia, or an inflammation of the eyelids, but which, by common care, is easily removed. If the sacculus be not much dilated, the discharge small, and produced only by pressure, the chief inconveniences are the weeping eye, and the gumming together of the lids after sleeping: but these, by being attended to, may be kept from being very troublesome; and if the disease makes no further progress, may be so regulated as to render any more painful process totally unnecessary. If the dilatation be considerable, the swelling is more visible, and the quantity of fluid is larger; it is also in this state more frequently mixed and cloudy, and more troublesome, from the more frequent necessity of emptying the bag; but if the patient be an adult, it may, even in this more dilated state of it, be kept from being very inconvenient.

If an inflammation comes on, the tumor is thereby considerably increased, the discharge is larger, as well during sleep as upon pressure; the skin covering it loses its natural whiteness and softness, becomes hard, and acquires an inflamed redness; and with the tears a mixture of something, which in colour resembles matter, is discharged, especially if the pressure be made with any force, or continued for any time.

When the parts are in this state, the contents of the bag have so much the appearance of purulent matter, that they are now generally considered as such, though Mr Pott and several others have been of a different opinion, considering the fluid as merely mucus under a different form; allowing, however, that pus is sometimes discharged. If the puncta lachrymalia be naturally large and open, and the inflammation confined to the surface of the sac, its contents will pass off pretty freely, and the skin will remain entire.

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But when the skin covering the lachrymal bag has been for some time inflamed, or subject to frequently returning inflammations, it most commonly happens that the puncta lachrymalia are affected by it, and the fluid, not having an opportunity of passing off through them, distends the inflamed skin; so that at last it becomes sloughy, bursts externally, and forms an opening in the most prominent part of the tumor, at which the tears and matter contained in it are discharged. When the opening thus formed is small, it

commonly heals again in a few days, but it bursts as soon as a considerable quantity of this fluid is collected; and it continues thus to collect and burst alternately, till the opening becomes sufficiently large to prevent any farther collection. This state of the disorder exhibits exactly the appearances of a sinuous ulcer, with callous, and sometimes with retorted edges; and this stage forms properly the real *fistula lachrymalis*. Tears, mucus, and purulent matter, are now abundantly discharged from the sore. When the bone beneath is found, this discharge is seldom either acrid or offensive to the smell, for the opening being in general in the under part of the tumor, the matter is readily evacuated; but when any of the contiguous bones are carious, they are not only found to be so by the introduction of a probe, but by the appearance, smell, and effects of the matter upon the neighbouring parts. In this case it is thin, fetid, and commonly so acrid as to fret and corrode the integuments most contiguous to the ulcer; and when the disorder is connected with scrophula or with lues venerea, which is by no means an unfrequent occurrence, the discharge and appearance of the sore will vary according as it happens to be combined with one or other of these diseases.

From what has been said, we may divide this disease into four general heads or states, under which all its more minute distinctions may be comprehended. The first consists in a simple dilatation of the sacculus and obstruction of the nasal duct, discharging, upon pressure, a fluid either quite clear or a little cloudy; the skin covering the bag being entire and perfectly free from inflammation. In the second, the tumor is somewhat larger; the skin which covers it is in an inflamed state, but entire; and the discharge made through the puncta lachrymalia is of a pale yellow or purulent colour. In the third, the skin covering the sacculus is become sloughy, and bursts; by which means the swelling is in some measure lessened: but the matter which, while the skin was entire, used to be pressed out through the puncta lachrymalia, now discharges itself through the new aperture. The ductus ad nares, both in this and the preceding state, are not otherwise diseased than by the thickening of its lining. In the fourth, the passage from the sacculus lachrymalis into the nose is totally obliterated, the inside of the former being either ulcerated or filled up with a fungus, and attended sometimes with a caries of the bone underneath.

In the first and most simple state of the disease, viz. that of mere obstruction without inflammation, much pains have been taken to restore the parts to their natural state and use, without making any wound or division at all. The introduction of a probe, the injection of astringent fluids, and a constant compression made on the outside of the sacculus in the corner of the eye, are the principal means by which this has been attempted.

Several years ago, M. Anel made a probe (fig. 37.) of so small a size as to be capable of passing from the eyelid into the nose, being introduced at one of the puncta lachrymalia, and passing through the sacculus and duct; with which probe he proposed to break through any small obstruction which might be found in its passage. He also invented a syringe (fig. 38.), the pipe of which is small enough to enter one of the puncta, and thus furnishes an opportunity of injecting a liquor into the sacculus and duct; and with these two instruments he pretended to be able to cure the disease whenever it consisted in obstruction merely, and the discharge was not much discoloured. The first of these, viz. the passage of a small probe through the puncta, has a plausible appearance; but will, upon trial, be found very unequal to the task assigned: the very small size of it, its necessary flexibility, and the very little resistance it is capable of making, are manifest deficiencies in the instrument;

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The disease
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Treatment
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M. Anel's
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syringe

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Of little
use.

Fistula Lachrymalis. ment; the quick sensation in the lining of the sac and duct, and its diseased state, are great objections on the side of the parts, supposing it were capable of answering any valuable end, which it most certainly is not.

That the passing a fine probe from one of the puncta lachrymalia into the nose is very practicable, is known from experience; but the pain it gives, and the inflammation it often excites, are much greater than any benefit which does or can arise from it. It is said that the principal use of this probe is to clear the little ducts leading from the puncta into the sacculus, and the obstruction of those ducts is often mentioned as a part of this disease. Hence one would be led to suppose that it was a circumstance which frequently occurred; whereas it is seldom, if ever, met with. Nor, even if it did happen, could it ever produce the disease in question; the principal characteristic of which is a discharge into the inner corner of the eye upon pressure made in the angle.

The syringe, if used judiciously while the disease is recent, the sac very little dilated, and the mucus perfectly clear, will sometimes be found serviceable; it gives no pain; and a few trials render the use of it by no means troublesome. There is very little occasion, however, to take much trouble, or to put the patient to so much uneasiness; for if the sac be emptied by compression, if the liquor which was to have been injected be applied to the puncta, they will absorb it as readily as the fluid which naturally passes through them.

216 Screw invented by Fabricius ab Aquapendente. Fabricius ab Aquapendente invented an instrument, which was so contrived as by means of a screw to make a pressure externally on the lachrymal bag; from the use of which, he says, his patients received much benefit. This instrument has been considerably improved by late practitioners, and is still recommended as very useful. See fig. 39.

All the good that can be obtained by compress and bandage, this screw is capable of procuring; but it is also subject to all the same inconveniences, arising from the impossibility of determining exactly the due degree of pressure; for if it be so great as to bring the sides of the upper part of the sac into contact, all communication between it and the puncta will be thereby stopped; if it be but slight, the accumulation will not be prevented; nor does it in either case contribute to the removal of the obstruction in the nasal duct, the primary and original cause of the disease. If the curative intention was to procure an union of the sides of the sacculus, as in the case of parts separated from each other by the formation of matter or sloughs, and the pressure could be made uniformly and constantly, possibly it might be so managed as to answer a valuable purpose; but as that is not the intention, the pressure, whether made by an instrument or by a common roller and compress, contributes little or nothing toward a cure.

When the disease is only beginning to form, if the lachrymal sac be frequently pressed with the finger, the contents of it will be discharged before they become acrid, and the complaint, though seldom to be cured in this manner, may be sometimes endured without any other assistance. But when the disease has advanced so far as to be in a state of inflammation, considerable relief may be obtained from such remedies as are found to be useful in inflammatory affections of other parts of the body, as blood-letting, laxatives, and low diet, together with saturnine applications to the parts affected. But when these fail, and it is found that the passage of the tears to the nose is completely obstructed, as the matter, if it does not burst outwardly, may be in danger of corroding the bone underneath, a different practice is to be followed.

In this state, an opening in the upper part of the sacculus lachrymalis becomes in general absolutely necessary; and as a wound made by a knife leaves a much less disagreeable scar

than that which necessarily follows the bursting of the skin, one being a mere simple division, the other a loss of substance; it will always be found best to anticipate the accident of bursting, by making the opening as soon as the integuments are in such a state as to threaten it.

For making this incision, authors have been very particular in their directions with regard to its place, manner, and form. But all that the surgeon need observe is, to take care to keep the knife at a proper distance from the juncture of the palpebræ, to begin the incision a very little above a line drawn from that juncture toward the nose, and to continue it downward so as to lay the sac completely open; and the best instrument to make it with is a scalpel of the common form, but of a small size. If the sacculus be already burst, the place of opening is determined; and the orifice may be enlarged with a knife, or dilated.

The incision being made, the contents of the tumor should be moderately pressed out; after which, some practitioners advise that the nasal duct should be searched for by means of a probe; and if found, that a piece of catgut, bougie, or lead, should be introduced, and kept there, its edge being bent a little downwards till the sides of the duct are skinned over and healed. In the mean time, the fore is to be dressed with simple pledgets of wax and oil, which are to be retained by means of adhesive plaster. As soon as the passage of the tears into the nose is sufficiently secured, the substance which has been left in it is to be withdrawn, and the wound healed.

228 During the last stage. The last state of this disorder is that in which the natural passage from the sacculus to the nose is so diseased as to be quite obliterated, or in which the bones are sometimes found to be carious. The methods hitherto described have all been calculated to preserve the natural passage, and to drive the lachrymal fluid again through it. In this attempt they are sometimes successful; but when every trial for discovering the nasal duct has been unsuccessful, recourse must be had to an artificial opening for the tears. In performing this part of the operation, the patient should be seated opposite to a window, with his head supported by an assistant. The surgeon is to place himself immediately before him, either in a sitting or standing posture. The canula of the trocar (fig. 40.) is now to be introduced to the under and back part of the lachrymal sac, and held with one hand, while the stilette is to be passed into it by the other, in a direction obliquely downwards and inwards, between the two spongy bones, till it reach the cavity of the nose, which will be known by some bloody mucus passing out at the nostril. As soon as the instrument has penetrated the nose, the opening should be made sufficiently large; then the stilette should be withdrawn, and a bit of catgut or bougie, or what is more cleanly and convenient, a leaden probe, is to be introduced, and the canula removed. One end of the probe ought to remain in the nose, and the other bent in such a way as to hang over the edge of the wound, and at the same time be in no danger of coming out. The fore is now to be covered with a pledget of lint spread with emollient ointment, and the whole retained with adhesive plaster. The probe must be removed every day or two, so as to allow it and the passage to be cleaned; and at each dressing some astringent injection should be thrown in, when the parts are to be dressed as at first. Several weeks will commonly be necessary for rendering the passage perfectly callous; but this must depend much upon the state of the parts, as well as the constitution of the patient.

After the passage is become sufficiently callous, the dressings and probe are to be withdrawn, and the parts cleared from any mucus with which they may be stuffed. The

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sides of the wound, now already sufficiently contracted, are to be laid together, and covered with some adhesive plaster. If this be ineffectual, the wound is to be touched with caustic, when the cure will generally be quickly completed. To give tone to the parts, moderate pressure should frequently be made upon the sac, either by the patient's finger or by the machine already mentioned, and this should be continued for a considerable time. Sometimes the disease returns after a cure has been made, owing to diseases of the constitution, carious bone contiguous to the fore, or sometimes to too small an opening having been formed. In this case a canula of gold, silver, or lead, is sometimes introduced into the artificial passage, and the skin healed over it; by which means the passage will afterwards remain completely open, and no disease of the constitution can ever affect it. We shall describe Mr Pellier's method of performing this operation, who has made several improvements on it.

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The patient is to be seated, and his head properly supported by an assistant; then the sac is to be laid freely open at its inferior part; the nasal duct is to be searched for with a firm probe, or with a conductor (fig. 41.) made for the purpose; and Pellier asserts that he never fails in finding it. As soon as this is discovered, a conical tube (fig. 42.), with a projection at the top, and another in the middle for securing it in its place, must be put upon the conductor, previously furnished with a compressor (fig. 43.), and it should be of such a size that the conductor may fit it exactly. The point of the conductor is now to be passed into the lachrymal duct; and being pushed in till it reaches the nostril, which may be known either by inserting a probe into it, or by a few drops of blood falling from the nose, the conductor is to be withdrawn; leaving the compressor upon the brim of the canula, which must be firmly pressed down with the left hand, while the conductor is removed with the other. This being done, the compressor must next be taken out; and to discover whether the canula be at a proper depth, a little milk or water should be injected thro' it. If the injection pass, it will show that the canula is properly placed. If, on the contrary, any obstruction occur, there will be reason to suspect that it is already pushed too far, and that it presses against the os spongiosum inferius; in which case the canula must be withdrawn, shortened, and reintroduced as before.

The fore ought to be kept open for eight or ten days after the operation with soft lint spread with emollient ointment, and the whole covered with a compress of soft linen secured with a bandage. An injection of milk and water should be daily passed through the canula; and as soon as the fore looks clean and healthy, the dressings should be entirely removed, and a piece of court plaster laid over it. In this state it is to be left to heal; but the plaster must be renewed, if matter appear to form beneath it. By this method Mr Pellier finds, that fistula lachrymalis, not depending upon diseases of the contiguous bones or of the constitution, may commonly be completely cured in two or three weeks, which, by the usual practice, might require several months.

CHAP. XV. Of Affections of the Nose.

SECT. I. Of Hemorrhages from the Nose.

WHEN the means mentioned for this complaint in the article MEDICINE have failed, recourse must be had to compression. Dossils of lint introduced into the nostrils are sometimes effectual; or the gut of some small animal, tied at one end, then introduced by a probe into the nose as far as the pharynx, and filled with cold water, or that and vine-

gar, and secured by a ligature, by adapting itself to all the parts, and pressing equally on them, has been attended with advantage. When these remedies likewise fail in their effect, a piece of catgut or wire may be introduced through the nose into the throat, and brought out at the mouth; a piece of sponge, or a bolster of lint of a size sufficient to fill the back-part of the nostril, is then to be fixed to it; the sponge is next to be drawn back and properly applied. Another is to be applied to the anterior part of the nostril and secured. The same may be done to the other nostril, if it be necessary; or the sponge may be of such a size as to fill the ends of both nostrils at the same time. By this contrivance the blood not finding an outlet, will soon coagulate, and prevent any farther evacuation.

SECT. II. Of Ozæna.

By this is understood an ulceration within the nose, which may be occasioned by external violence, by exposure to cold, by irritating substances, or by whatever produces inflammation in the membrane lining the nostrils. Sometimes it arises from venereal infection; and in this case the discharge becomes so acrid as to corrode, and produce caries in the bones of the nose. When the disease is local, and not depending upon any constitutional affection, astringent solutions are found to be the most useful, such as a decoction of bark or that mixed with alum. Dossils of lint dipped in these are to be introduced into the nostrils three or four times a-day, or some prefer the injection of such fluids by means of a syringe as being more effectual. If stronger astringents be necessary, a solution of styptic powder ought to be used. At bed-time an ointment prepared with zinc or with lapis calaminaris ought likewise to be applied. Upon some occasions the application of a blister to the temple has cured the disease.

Instances, however, occur, where the discharge is occasioned by a collection of matter within the antrum maxillare; and then it is apt to resist every effort till a proper outlet be given to it.

When the complaint is owing to venereal infection, the primary disease is to be attended to, and mercurial preparations are to be applied to the part; but when the bones are carious, till these are removed we need neither expect that the discharge will cease, nor the disease be otherwise completely cured.

SECT. III. Of Imperforated Nostrils.

SOMETIMES the nostrils are in part or entirely obliterated. This may be owing to burns; small-pox; different kinds of sores, especially those of a venereal nature; and sometimes it is the effect of original conformation, for it has been observed in new-born children.

When any opening appears in the obstructed nostril, it may be readily dilated by the introduction of a furrowed probe, and then cutting upon it in the course of the adhesion: but when no passage appears, the operator must endeavour, by means of a scalpel, to discover one of the nostrils; and when discovered, it must be enlarged by a director and bistoury, as in the former case. The other nostril is to be treated in the same manner. After the openings are formed, they might be preserved of a proper size by the introduction of dossils of lint, which should be frequently cleaned or renewed; but metallic tubes answer the purpose better, and allow the patient to breathe freely through them till a cure be performed. Previous to their introduction, they ought to be covered with soft leather spread with emollient ointment, and retained till the sores are completely healed.

CHAP. XVI. *Of Affections of the Mouth and Throat.*SECT. I. *Of the Division of the Parotid Duct.*

WHEN the parotid duct is divided, the saliva which it transmits passes over the cheek instead of going into the cavity of the mouth.

When the surgeon is called to a recent division of the duct, he ought to lay the divided ends of it as exactly together as possible, and to retain them in their situation till they are united by adhesive plasters, or by the twisted suture if there be considerable retraction of the parts. But when the portion of the duct next the mouth is entirely obliterated, an artificial passage must be made into the mouth, and an union formed between the opening and that part of the duct which proceeds from the parotid gland. The artificial passage ought to be as much as possible in the direction of the natural duct. For this purpose a perforation of a proper size is to be made obliquely into the mouth with the trocar (fig. 44.), from the side of the wound exactly opposite and contiguous to the under extremity of the upper portion of the duct; and then a piece of leaden probe of the size of the perforator should be introduced by means of the canula, and be kept in the cheek till the sides of the opening become callous; when the lead being withdrawn, the extremities of the artificial and natural ducts are to be brought into contact, and retained there by adhesive plaster till the cure is completed. Another method has, in a few instances, been followed by Mr Latta (see his *System of Surgery*), of introducing one end of a bit of catgut into the artificial opening, and bringing it out at the mouth, while the other is introduced a little way into the extremity of the natural duct, and retained by adhesive plaster till the wound is healed. Whichever way the operation is done, the patient should live upon spoon-meat, and make as little motion as possible with his lips or jaws.

SECT. II. *Of the Hare-lip.*

THE hare-lip is a fissure in the upper lip, very seldom in the under one. It is attended with want of substance, and has its name from a resemblance to the lip of a hare. In general it is only a simple fissure, though sometimes it is double; in which case it renders a cure more difficult to be executed. There are many lips where the want of substance is so great, that the edges of the fissure cannot be brought together, or at least where they can but just touch, and then the attempt should be forborne. It is likewise improper in infants, and ought not to be performed till several months after they have been weaned, when they will have acquired more strength to undergo the operation, and will be less liable to be attacked with bowel complaints, which frequently make them cry at an earlier period of infancy.

In proceeding to the operation, the patient, if a child, should be secured upon a person's knee, or rather perhaps upon a table; but if an adult, he is to be seated upon a chair, in a proper light. The frænum connecting the gums to the upper lip is to be divided; if a fore-tooth project so much as to prevent the parts from being brought properly together, it is to be extracted; or when the fissure runs through the bones of the palate, if a small portion of the bone project, this must be removed. Matters being so far adjusted, the operator is to lay hold of one side of the fissure between the thumb and fore-finger, or between the forceps (fig. 45.), then with a pair of sharp and very strong scissars (fig. 46.), or with a scalpel, to cut off a thin portion of the lip, and to repeat the same thing upon the other side of the fissure, so as to render the whole edges of the fissure completely

raw; by which, if the operation be properly performed, a piece will be separated in form like an inverted V. After the incisions have been made, the vessels should be allowed to bleed freely to prevent inflammation; and when the bleeding has ceased, the sides of the wound are to be brought accurately together, and kept in that state by the twisted suture. The first pin ought to be as near as possible to the under edge of the lip; another is to be inserted near the upper angle; and if the patient be an adult, a third pin will generally be necessary, half way between the other two. In passing them, they ought to go rather deeper than half through the lip, that the edges of the wound may be kept properly in contact. An assistant now keeps the parts together, while the operator applies a firm waxed ligature first to the under pin; and having made three or four turns with it in the form of an eight figure (fig. 47.), it should then be carried about the second, and in a similar way about the third, care being taken that the thread be drawn of a proper tightness. After the ligature is secured, a piece of lint, covered with some mucilage, should be laid over the wound to protect it from the air; and this is commonly all the bandage necessary. When, however, from a great want of substance, the retraction has been considerable, some advantage is derived from the use of adhesive plasters applied to the cheeks and tied between the pins. During the time of the cure the patient should be fed upon spoon-meat, and prevented from making any exertion with the lips, otherwise the cure might be considerably retarded. At the end of five or six days the pins may be taken out, when the parts will commonly be found completely united.

In the case of a double hare-lip, the operation should be first done upon one fissure; and when a cure is completed there, it may be done safely upon the other.

SECT. III. *Of Extirpation of Cancerous Lips.*

THE under lip is much more frequently attacked with cancer than the upper, or indeed than any other part of the body: And as little dependence is to be placed upon external applications or internal remedies, recourse must be had to the knife as the only certain method of cure.

When the disease has not attacked any considerable part of the lip, the diseased part is to be cut out, and the wound cured by the twisted suture. The operation ought therefore to be performed early, to allow the parts to be brought properly together. The general steps of the operation are nearly the same as in the operation for hare-lip, and therefore need not be repeated. It is only to be observed, that all the diseased parts are to be removed, taking care to make the cut in such a way as will most readily admit of the twisted or hare-lip suture. When the parts can be brought together, the lip will have nearly the same appearance as in the operation for hare-lip; but when the disease spreads over a considerable part of the lip, so as to prevent the sound parts from being united after the diseased parts have been removed, all that can be done is to remove the part affected, secure the bleeding vessels, and dress the sore like any other recent wound.

SECT. IV. *Of Affections of the Teeth.*

IN dentition the gums inflame and swell about the parts where the teeth are afterwards to appear; the child is continually rubbing the gums with its finger; the saliva is commonly increased in quantity, though sometimes the contrary happens; sometimes the bowels are remarkably costive, tho' more frequently the reverse: there is generally quick pulse, with heat, and other symptoms of fever; and on some occasions these symptoms are attended with convulsions. The means found to be most useful here are such as

Affections
of the
Teeth.

are most effectual in allaying irritation; as opiates, blisters, and especially warm-bathing. When these fail, cutting the gum by means of a flane (fig. 48), over the approaching tooth, is frequently found to remove every symptom; but this ought to be done earlier than it commonly is to have the full effect. Whenever the symptoms give reason to think that a tooth is approaching, the gums should be cut freely over that part where the teeth may be first expected. When the symptoms recur, the operation should be repeated. A crucial incision is attended with still more effect; and the bleeding which afterwards takes place is of considerable service. The incision should always be carried as far as the tooth, which ought to be somewhat exposed; and when properly done, is frequently followed with immediate relief. Sometimes the same kind of symptoms attend the cutting of the second set, particularly of the dentes sapientie. When this is owing to the thickness of the gums, scarifying gives the greatest relief; but sometimes it is for want of room in the jaw, and then the tooth should be drawn.

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Derangement
of the
teeth.

Derangement of the teeth happens more frequently in the second than in the first set, and more commonly in the fore than in the back teeth. This may be owing to the first set remaining in the jaw after the second have appeared. Another cause is a waste of space in the jaw; and a third is a mal-conformation of the teeth, where they are too large in proportion to the jaw, and therefore overlap each other. The remedy is the same in each of these cases, viz. to extract the teeth which stand in the way of the rest, to allow those which are out of their place to come into the row, and put on a more uniform appearance.

The usual method of moving teeth which are out of the row is, by fixing them with a ligature to the nearest teeth; or the same thing is done by metalline plates or pieces of wire. But these methods have not been found fully to answer the purpose intended, though in some cases they may be useful. When one or more front teeth are accidentally drawn out of the jaw, they ought to be immediately replaced. When the teeth are broken over or otherwise injured, they may be supplied with others transplanted from the jaws of another person; but this can only be done when the sockets have been newly emptied, for after inflammation comes on it is impracticable. In these cases the inflammation must be allowed to subside, and then artificial teeth can be readily adapted.

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Of loose
teeth.

When the teeth are loosened by external violence, by falls and blows, or by improper use of instruments in pulling diseased teeth in the neighbourhood of sound ones, they may again be made tolerably fast by pressing them as firmly as possible into their sockets, and preserving them so with ligatures of catgut, Indian weed, or waxed silk, and keeping the patient upon spoon-meat till they are firm. When loose teeth are owing to tartar, nothing will fasten them till the cause be removed; and this ought to be done early, otherwise it will have no effect. Frequently the teeth become loose from a sponginess in the gums, often, but improperly, attributed to scurvy. The best remedy is scarifying the gums deeply, and allowing them to bleed freely; this should be repeated till they are fully fastened. Mild astringents, as tincture of bark, are here attended with good effects, tho' those of a strong nature will certainly do harm. The mouth should be frequently washed with cold water strongly impregnated with these, and the patient should not use the teeth which have been loose till they become firm again. The loosening of the teeth in old age cannot be remedied, as it is owing to a wasting of their sockets, from which the teeth lose their support.

The teeth sometimes become yellow or black without

any adventitious matter being observed in them; at other times they become foul, and give a taint to the breath, in consequence of the natural mucus of the mouth, or part of the food remaining too long about them. The most frequent cause of foul teeth is the substance called *tartar*, which seems to be a deposition from the saliva, and with which the teeth are often almost entirely incrustrated. When this substance is allowed to remain, it insinuates itself between the gums and the teeth, and then gets down upon the jaw in such a manner as frequently to loosen the teeth. This indeed is by far the most common cause of loose teeth, and when they have been long covered with this or with any other matter, it is seldom they can be cleaned without the assistance of instruments. But when once they are cleaned, they may generally be kept so by rubbing them with a thin piece of soft wood made into a kind of brush, and dipped into white-wine vinegar; after which the mouth is to be washed with common water.

When the teeth are to be cleaned by instruments, the operator ought, with a linen cloth or with a glove, to press against the points of the teeth, so as to keep them firm in their sockets, with the fingers of the one hand, while he cleans them with the necessary instruments, fig. 51. n^o 1, 2, 3, 4, 5, held in the other; taking care not to scrape them so hard as to loosen them, or to rub off the enamel. This being done, the teeth should be rubbed over with a small brush, or a piece of sponge dipped in a mixture of cream of tartar and Peruvian bark. The same application may be made to the teeth for a few days, after which they may be kept clean as already directed.

The teeth are sometimes covered over with a thin dark coloured scurf, which has by some been mistaken for a wasting of the enamel, but which is only an extraneous matter covering it. By perseverance this may be cleaned off as completely as where the teeth are covered with tartar; but it is apt, after some time, to appear again. When this is observed, the same operation must be repeated.

For the purpose of applying powders or washes to the teeth, a brush or a sponge is commonly employed; the latter is certainly preferable, as being less in danger of wearing down the enamel, or of separating the teeth.

The causes producing toothach may be, exposure of the nerve of a tooth, by breaking or wasting of the enamel, inflammation in or about the tooth, or from sympathy when distant parts are affected, as the eye, the ear, the stomach, or the uterus, as in time of gestation. After toothach has once been produced and removed, it is apt to return by exposure to cold, by taking hot liquids, by hard bodies pressed against the nerve in the time of chewing, by the use of a pick-tooth, &c.

With respect to the cure of this disease, no rule can be laid down which will answer with certainty upon all occasions. No remedy has yet been discovered which will at all times even moderate the pain; relief, however, is frequently obtained from acrid substances applied to the tooth, so as to destroy the irritability of the nerves, such as opium, spirit of wine, camphire, and essential aromatic oils. When these fail, blisters behind the ear, or destroying the nerve by the cautious use of strong acids, or by a red hot wire frequently applied to the part, have been attended with advantage.

When a black or mortified spot appears on a tooth, if it be quite superficial, it may be removed; but if it go through the thickness of the enamel, it will be more advisable to let it remain.

When a small hole breaks out in a tooth, particular attention should be paid to prevent the admission of air. Tin, lead, or gold-leaf, commonly employed for this purpose, sometimes give relief for many months, or even years; but

at

Affections of the Teeth. at other times are of little advantage, and in some instances create great pain. Gum-mastich or bees-wax are frequently employed, and can be made to fill the cavity of the tooth still better than metalline substances. When stuffing is to be employed, it ought to be done in the intervals of the fits of toothach, otherwise it will give great uneasiness. When it is to be used, the whole cavity of the tooth should be filled; and this is to be done with the instruments, fig. 52. n^o 1, 2, 3.

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Method of
extracting
the tooth.

When the remedies made use of for the removal of toothach have failed in their effect, and it is found that the complaint still continues, it will be necessary to extract the tooth. In doing this, it may be observed, that all the teeth may be pulled to either side, excepting the dentes sapientiae of the lower jaw, which ought to be pulled outwards, otherwise the jaw may be splintered. As soon as the socket is cleared of blood, if the tooth be not much spoiled, it may be immediately replaced, when it will become as useful as before. It is difficult, however, to replace the large grinders, on account of their diverging roots. The more perpendicularly the teeth are pulled, the less contusion and injury will be done to the jaws and alveoli. But as no instrument has been yet invented capable of effecting this properly, surgeons are obliged to be contented with an instrument which acts in a lateral direction. One of the best is that (fig. 53.) in form of a key, with a claw and fulcrum. Previous to the operation, this should be covered with a linen rag, to prevent the gum from suffering. After dividing the gum, or separating it from the tooth, the claw is to be fixed as deep between the teeth and gum as possible. Then the fulcrum is to be applied on the opposite side. The surgeon may now, with one turn of the handle of the instrument, pull the tooth out at once. But the turn should not be effected by a sudden jerk, but in the most cautious and slow manner. When it happens to be one of the great molares, whose roots diverge very much, and when they are firmly fixed, after only loosening it with the first pull, the claw of the instrument is to be applied to the other side of the tooth, and the turn given in a contrary direction to the first. After it has been sufficiently loosened in this manner, it is to be laid hold of by a common teeth forceps (fig. 54.), and extracted in the easiest manner. Upon extraction of the tooth, any detached splinters occurring are to be immediately removed. Should any considerable hemorrhagy take place, the patient may take some cold water, vinegar, or spirit of wine into his mouth, and dossils of lint may be introduced into the socket. After all these fail, recourse must be had to the actual cautery.

When stumps occur from caries, or when the teeth have broken in time of the extracting, the common key will sometimes remove them; if that fail, the punch (fig. 55.) is to be used. The operator, having this instrument in one hand, is to place the fore finger of the other, with a piece of cloth wrapped round it, upon the inside of the jaw opposite to the stump, to protect the neighbouring parts.

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Of trans-
planting
teeth.

Teeth can never be transplanted with propriety in childhood or in old age. The constitution must be free from those diseases which affect the gums. The tooth to be transplanted must be taken from a person of a sound constitution, otherwise it will convey infection. To guard as much as possible against infection, it should be immersed for a few minutes in lukewarm water, and then well dried and cleaned. It ought to fit the socket exactly; if it be too large, it may be filed down, avoiding the enamel as much as possible. The surface of it should be at first on a level with the rest, or rather a little more depressed, that it may be as secure as possible in its place. If the tooth fit the socket properly, there will be no occasion for using a

ligature to fix it; but if a ligature be found necessary, it may be made of threads of fine silk properly waxed. After the operation is finished, the patient ought to avoid whatever may be in danger of shaking the tooth, and this is to be attended to till the tooth is perfectly firm. He should also guard against cold and moist air, and live upon spoon-meat.

SECT. V. Of Boils and Excreescences of the Gums.

GUM boils may arise from cold or from external violence, &c. but most frequently they are the consequence of toothach. The complaint begins with pain attending a tumor on the parts affected; by degrees the side of the face swells considerably; the tumor of the gum now begins to point; and if it be not opened, it bursts and gives the patient immediate relief. When the boil is owing merely to inflammation, after the matter is evacuated, the complaint goes off; but when it proceeds from a caries of a tooth, it will continue as long as the cause remains; the tooth therefore ought to be extracted. After the abscess has burst, if the matter continue to be discharged, it may sometimes be dried up by injecting some astringent liquor; but the most effectual method is to lay the abscess fully open, and to heal it from the bottom by dossils of lint. Sometimes abscesses occur of a more obstinate nature, owing to a carious state of the jaw. In that case suppuration ought to be promoted, and the part laid open as soon as matter is formed; keeping the passage open for the discharge, being the only means for effecting a cure.

Excreescences of various degrees of firmness sometimes grow upon the gums. Some are soft and fungous, while others are of a warty nature. In general they are not attended with pain. They frequently originate from caries of the teeth, or of their sockets; in which case the removal of the spoiled teeth, and the subsequent exfoliation of the carious part of the jaw, will often accomplish a cure. But when this does not happen, the tumor should be removed as soon as it becomes troublesome, otherwise there may be danger of its ending in cancer. The removal may be effected by a ligature or knife, according as the tumor may have a narrow or broad basis. It is sometimes necessary to use a speculum oris to keep the mouth open. After the tumor is extirpated, the wound should be allowed to bleed freely, to prevent subsequent inflammation. When the hemorrhagy proceeds too far, it should be restrained by the application of spirit of wine, or tincture of myrrh, or solution of alum, &c. and should these prove unsuccessful, the lunar caustic will seldom fail of having the desired effect. No dressings can be applied; but for some days after the operation, the mouth should be frequently washed with a warm emollient decoction; and the cure will be afterwards promoted by the application of some gently astringent liquor, as port wine, tincture of roses, &c.

SECT. VI. Of Abscesses, &c. in the Antrum Maxillare.

THIS disease is known by a pain and uneasiness beginning in the cheek, and extending upwards to the eyes, nose, and ears, together with a swelling, which in the latter stages of the disease tends to a point, most frequently in the cheek. Sometimes a discharge ensues between the roots of the back-teeth, when they happen to penetrate the antrum. Sometimes a discharge of matter from the nostrils takes place, particularly when the patient lies on the side opposite to the tumor. The disease may arise from cold, or whatever produces inflammation in general; but the most common causes are violent fits of the toothach, occasioning excessive pain and inflammation of the membranes of the nose and antrum.

The cure is performed by giving a free discharge to the

Boils and
Excreescen-
ces of the
Gums.

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Of gum
boils.

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Excreescen-
ces in the
gums.

Ranula.

Plate
488.

contents of the tumor: and this is done in two ways; either by extracting one of the two anterior great molares, which are situated under the antrum, and making a perforation with a round trocar (fig. 49.) through the bottom of the socket; if this has not been already perforated by the fangs of the tooth or eroded, in which case the matter will pass out immediately after the extraction: or the perforation may be made by the instrument represented in fig. 50. thro' that part of the antrum which projects outwardly over the molares. As most people wish to avoid the pulling of a tooth, when it does not appear to be absolutely necessary, the perforation is commonly made in the way last mentioned. Some authors, however, object to this, as not giving a sufficiently depending opening to the matter. As soon as the matter is discharged, a plug may be introduced into the perforation, which may be removed frequently to allow the matter to pass out, and to admit astringent solutions of bark, &c. to be occasionally thrown into the cavity of the antrum. In this way a cure is obtained, if the bones be sound; but if they are carious, it is impossible to expect a cure till the diseased portions of the bone exfoliate and be removed. When cloated blood is formed in the antrum, it is to be removed in the same manner. Sometimes the tumor of the cheek is owing to a swelling of the bones, and no matter is found in the antrum: In that case the operation does harm. No external application has yet been discovered for removing such a swelling, though a long continued course of mercury has been found to be of some service.

SECT. VII. Of Ranula.

THIS is a tumor under the tongue, most frequently owing to an obstruction in one of the salivary ducts. Sometimes it contains matter like the synovia of the joints, sometimes a fatty matter, now and then stony concretions, but most commonly a fluid like saliva. It often acquires such a size as to prevent sucking in infants, or mastication and speech in adults. When the person attempts to speak, he only makes a croaking noise: hence the name of the disease.

The best mode of treatment is to lay the tumor fully open by means of a scalpel or large lancet, to evacuate its contents completely, and then to wash the cavity with any mild fluid, as milk and water. If the sore be difficult to heal, tincture of bark or other astringents may be used. When the tumor is observed to be filled with a fatty or any other firm substance, it ought to be removed entirely. The only application necessary in the time of the cure, is the frequent injection of milk and water, or any other mild fluid, by means of a syringe.

SECT. VIII. Ulcers within the Mouth.

WHEN ulcers of the mouth arise from a general affection of the system, this must be removed before a cure can be expected. When they originate from sharp points in the teeth, these are to be filed off, and some astringent solution taken occasionally into the mouth. Notwithstanding these and other remedies, the sores sometimes becomes worse, discharging a thin fetid sanies, attended with much pain, and putting on every appearance of cancer. In this situation, extirpation is the only thing that can effect a cure. If the sore be only superficial, it may pretty readily be extirpated; but when deep seated, it may sometimes be necessary to cut through the whole substance of the cheek, and heal the sore by the hare-lip suture. When the tongue is the subject of operation, the operator ought to be ready to take up the bleeding vessels by the tenaculum or the needle. Along with ligature, it may be necessary to use astringent gargles, or a mixture of vitriolic acid in water. If these fail, the potential or even actual cautery must be used.

SECT. IX. Division of Frænum Lingue.

Division of
Frænum
Lingue.

SOMETIMES the frænum lingue extends to the point of the tongue, and tying it down; whereas, in the natural state, it ends about one-fourth of an inch farther back. When this is the case, it is to be divided, guarding against wounding the neighbouring vessels, or the ends of the salivary ducts. The division may be made with a common scalpel, but still better with a pair of very sharp scissars with blunt points.

The child being laid across the nurse's knee, the surgeon should open the mouth, and raise the tongue with the two first fingers of the one hand, while with the other he introduces the scissars, and divides the frænum in the middle, and as far back as is necessary.

SECT. X. Of Enlargement of the Tonsils and Uvula.

THE tonsils sometimes grow so large and hard as to become incurable, and even to threaten suffocation. The tumors here have been commonly considered as to be of a scirrhus nature; but they are neither attended with shooting pain, nor are they apt to degenerate into cancer; neither do swellings return after the tonsils have been extirpated: hence they ought not to be removed till by their size they impede deglutition or respiration; but whenever they do this, they may be removed with safety. The only proper method of removing them is that by ligatures, which are not only void of danger, but seldom fail to perform a cure. If the base of the tonsil be smaller than the top, the ligature is to be used as for polypi in the throat; but however broad the base of it may be, much difficulty will seldom occur in fixing it, for the swelling is always very prominent. In diseases of this kind both tonsils are generally affected; but if the removal of one of them forms a sufficient passage for the food, the other may be allowed to remain. When, however, it is necessary to extirpate them both, the inflammatory symptoms produced by the extirpation of the first should be allowed to subside before any attempt be made to remove the other.

When the form of the tonsils happens to be conical, so that the ligature would be apt to slip over their extremities, Mr Cheselden has recommended a needle (fig. 56.), with an eye near the point: a double ligature being put into the eye, the instrument is to be pushed through the centre of the base of the tumor, and the ligature being laid hold of by a hook and pulled forwards, the instrument is to be withdrawn; then it is to be divided, and so tied that each part may surround one half of the tumor. This method however is scarcely ever found to be necessary.

Enlargements of the uvula, from inflammation or from other causes, may generally be removed by the frequent use of astringent gargles, as of strong infusions of red rose-leaves or of Peruvian bark. But when these fail, and the enlargement is so considerable as to give great uneasiness by impeding deglutition, irritating the throat, and so causing cough, retching, and vomiting, extirpation is the only thing upon which any dependence can be placed. Excision is the readiest method when the uvula is only elongated; but when the size is considerable, dangerous hemorrhages sometimes attend this method; on which account a ligature is preferable. The operation may be readily performed by those of the common kind; some prefer the curved probe-pointed bistoury.

In performing the operation, the speculum oris (fig. 57.) is necessary to keep the mouth sufficiently open, and the uvula should be laid hold of by a pair of forceps or a small hook, so as to keep it firm, and prevent it from falling into the throat. After the operation, if the bleeding be considerable, it may be checked by astringent gargles, or by touch.

Scarifying touching the part with lunar caustic ; but this will seldom be necessary.

When a ligature is to be employed, it may be readily done according to the method recommended in the extirpation of polypi. A double canula with a ligature may be passed through the nose, or the ligature may be applied according to Cheselden's method in extirpation of the tonsils.

SECT. XI. *Of scarifying and fomenting the Throat.*

In inflammatory affections of the throat, the means commonly employed are gargles, fomentations, scarification, or top-bleeding. Gargles are useful for cleaning the fauces from thick mucus or other fordes ; they may likewise be useful in cases of ulceration. In relaxation of the parts, they are employed to advantage when made of astringent materials. Fomentations may be of some use when externally applied ; but the steam of water, &c. drawn into the throat, by means of Mudge's inhaler (fig. 58.), is preferable. Sometimes it is necessary to draw blood from the part affected. Here recourse may be had to scarifying with a common lancet, the tongue being depressed with a spatula. It may be still more readily done by the scarificator (fig. 59). After a sufficient number of punctures have been made, the flow of blood may be promoted by the patient's frequently applying warm water to the punctures. When abscess forms, notwithstanding the use of these remedies, the matter may be discharged with the scarificator already mentioned.

CHAP. XVII. *Of Diseases of the Ear, and Operations performed upon it.*

²⁴⁵ Sometimes a thin membrane is spread over the mouth of the external passage, while at other times a considerable part of the passage is filled up with a fleshy looking substance, occasioning deafness. When the first circumstance occurs, the skin is easily divided by a simple incision, and the accretion of its sides may be prevented by a dofill of lint or a bit of bougie inserted between the edges of the wound, and daily cleaned and returned till the part be rendered callous.

When the other cause is present, the incision must be continued considerably deeper, till the resistance be removed, or till the instrument reach near to the membrane of the tympanum, when the operator should desist, lest the membrane should be wounded ; then the same kind of treatment may be followed as in the former case. The proper time for performing the operation is when children usually begin to speak ; for previous to this the patient may be too weakly to bear it, and after this speech would be impeded.

Sometimes the meatus externus is entirely wanting in the temporal bone. For this an opening through the mastoid process has been proposed ; but the operation has not been performed, at least in this country.

²⁴⁶ Children sometimes push hard bodies into their ear, or different kinds of insects occasionally creep into it, so as to cause considerable uneasiness. Substances lying near the outer end of the passage may generally be extracted by the small forceps represented in (fig. 60.) ; but round, hard bodies situated deeper in the passage are more readily removed by a crooked probe. When insects are deep seated in the ear, they ought first to be killed, by filling the passage with oil, or any other fluid which proves noxious to them, without hurting the tympanum. They may then be washed out by injecting warm water frequently by means of a syringe.

Wax is one of the most frequent causes of deafness, and

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it may be readily detected by looking into the ear in a clear sunshine.

Various methods have been proposed for removing wax from the ear ; but one, not inferior to any, is to throw in frequently, by means of a syringe (fig. 61.), warm milk and water, or water in which a little soap has been dissolved. Assistance may likewise be given here, by using along with the injection a blunt probe or fine hair pencil, by which the bottom of the passage may be cleared out. After the wax is removed, the patient ought to guard against the effects of cold by introducing a little wool for some time into the meatus.

When deafness is owing to a deficiency of wax in the ear, a little oil of almonds, or even oils of a hotter nature, or soap, or galbanum &c. have been of service.

²⁴⁷ Purulent matter is now and then formed in the ears of adults, but oftener in those of children. Sometimes it is produced by ulcers situated in the lining of the meatus, or upon the membrane of the tympanum. It seems to be merely a local affection, and does not, as many have supposed, originate from morbid humours of the system. The remedies best calculated for removing it are such as are of a moderately astringent nature, as a weak solution of saccharum saturni. A little of this may be dropped in two or three times a-day, but it is still better to use a syringe. If the discharge has continued long, it may be proper, in addition to the other applications, to keep open a small blister for some time in the neck, arm, or wherever it may be thought most convenient.

It sometimes happens, particularly in old people, that, from exposure to a stream of cold air, the tympanum becomes affected, and a noise is heard by the patient like the rushing of water. In other cases the patient is incapable of accurately distinguishing the words of some persons speaking in a loud tone of voice ; or, in mixed companies, he hears only a confusion of sounds. Complaints of this kind frequently originate from a relaxation of the soft parts of the tympanum ; and though a complete cure is not very frequently performed, yet considerable advantage is sometimes derived from the use of hot stimulating oils, and from keeping the part warm at the same time with a little wool. When deafness arises from affections of this nature, some assistance may be derived from collecting the sound, so as to make a stronger impression upon the internal ear. A variety of instruments have been invented for this purpose. Some use a convoluted tube as is represented in fig. 62, (see TRUMPET) ; others a sort of cup, fig. 63. which is concealed under the hair, and fixed to the head with straps.

In scrophulous habits, suppurations sometimes occur in the neighbourhood of the ear, and penetrate into the external passage, or into the tympanum itself ; after which it is not unusual for the small bones of the ear to lose their connecting membrane, and to be discharged along with the matter, and for caries to ensue in the tympanum ; in consequence of which a high degree of deafness is produced, which can never be removed. In such a situation little else can be attempted than to preserve the parts clean and free from smell, which is readily done by injecting a little warm milk and water morning and evening by means of a syringe. If this be neglected, the matter from the carious bones is apt to become offensive ; and it commonly continues till the diseased parts are either dissolved and discharged, or probably during the life of the patient.

Besides the affections which may arise in the meatus externus, and may be the cause of deafness, others may occur in or about the meatus internus or eustachian tube, which may have in part the same effect, though by no means in the same degree. Inflammation and its consequences may originate

Diseases of the Ear.

247 Of suppurations of wax in the ear.

248 Deficiency of wax.

249 A discharge of matter from the ear.

250 Affections of the Eustachian tube.

The Wry Neck.

originate in the cavity of the tube, or swellings or ulcers in the throat may affect it so as to cause some degree of deafness. When this is the case, it is practicable to introduce a pipe, fig. 64. crooked at the extremity, through the mouth or nose, and then to inject into the mouth of the eustachian tube any mild fluid which may be thought fittest for the purpose, though no great dependence is to be placed upon the attempt.

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Of perforating the lobes of the ears.

Formerly piercing the lobes of the ears was sometimes recommended in complaints of the head, and was considered as a chirurgical operation; but it is now never practised, unless for the sake of ornament. As the substances suspended at the ears are sometimes so heavy as to tear down the parts, the perforation should be made as high on the lobes as can be done with propriety, and care should be taken that the perforations be made exactly in the corresponding parts of the ears. Previous to the perforation the lobes may be marked with ink; then the patient being seated, the lobe of the ear should be stretched upon a piece of cork placed beneath it, and perforated with an instrument, fig. 65. The cork is then to be withdrawn with the point of the instrument sticking in it: A small piece of lead, or silver, or gold-wire, is now to be inserted into that part of the instrument which remains in the ear, and on being drawn into the perforation, the wire is to be left in it. By rubbing it with oil, and moving it daily, the passage will soon become callous, and fit for receiving the ornament intended for it.

CHAP. XVIII. *Of the Wry Neck.*

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Causes of wry neck.

WRY neck may be owing to different causes; as contraction of the skin in consequence of burns, or other kinds of sores; relaxation of the muscles of one side of the neck, particularly the mastoid, while those of the other side continue to act with vigour; preternatural contraction of the muscles of one side of the neck, the others having their usual power; or, a bend in the vertebræ of the neck.

When the disease is owing to a contraction of the skin, this is to be divided through the whole of the contracted part, guarding against cutting the external jugular vein.

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Treatment.

When the contraction of the mastoid muscle is the cause of the disease, the muscle should be divided by gentle strokes, so as to run no risk of wounding the great vessels situated under it. When an incision is made either with a view to divide the muscle or the skin, the head is afterwards, by means of a machine (fig. 66.), to be kept in a proper posture during the cure until new granulations form and fill up the empty space. When the disease is merely owing to a curve of the bones of the neck, the same kind of machinery may be useful with that recommended for cure in the other parts of the spine. But sometimes the disease arises from an affection of the bones of a more serious nature. Here the disease in the vertebræ commonly begins with a slight pain, which gradually becomes worse, and the head is turned over to the sound side. As the disease becomes worse, a fulness can be observed very painful to the touch; and moving the head becomes so distressing as to be almost impracticable. The only method which has been found to be effectual in this case, is the insertion of a pea-issue on each side of the tumor, and retaining it till the pain and stiffness are entirely removed.

CHAP. XIX. *Of Bronchotomy and Oesophagotomy.*

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Bronchotomy.

THE operation of bronchotomy is an incision made in the trachea, to make way for air into the lungs, when respiration is obstructed to such a degree that life is in danger. If the patient's breathing be already stopped, the operation ought to be done with the greatest expedition; using any

instrument which will most readily make an opening in the trachea, as the delay of a few moments will often put a period to the person's existence. Experience has shown, indeed, that in by much the greater number of cases, by a total stoppage of respiration for only five or six minutes, life is irrecoverably destroyed.

In performing the operation, where, from the nature of the case, sufficient time is allowed, the patient is to be laid on his back upon a table, and properly secured by assistants. A longitudinal incision is to be made, about an inch and an half long, through the skin and cellular substance; beginning at the under edge of the thyroid cartilage; the sterno-hyoid and thyroid muscles are then to be separated; the thyroid gland is to be avoided as much as possible, on account of its vascularity. As soon as the trachea is laid bare, the bleeding-vessels, to prevent coughing, are to be secured; then, with a common lancet, a puncture is to be made as high as may seem practicable between two rings of the trachea, of such a size as to admit the introduction of a double canula (fig. 65.), large enough to allow the patient to breathe freely, and of such a length as neither to be in danger of slipping out, nor of irritating the back part of the trachea. Such a canula has long been recommended by Doctor Monro in his course of surgery. Previous to the introduction the canula may be put through several plies of linen compress; or these may be first slit half way down, and applied so that any of them may be removed and replaced at pleasure. This double canula is to be fixed by a strap round the neck; and when mucus obstructs the passage of the instrument, the inner tube can be withdrawn, cleared, and readily replaced; while the patient is, during this time, breathing through the outer one; and by means of a screw the tubes can be regulated according to the motions of the trachea. After the canula is fixed, it ought to be covered with a piece of muslin or crape, to prevent the admission of dust, insects, &c. As soon as the causes inducing suffocation are removed, the canula is to be withdrawn, and the skin immediately brought over the orifice, and retained there by a slip of adhesive plaster.

By oesophagotomy is understood the cutting open the oesophagus, to allow substances sticking in it, and which cannot be extracted otherwise, to be removed. It is only to be done, however, in cases of the most extreme danger, as it is attended with much hazard; and there are only two instances yet on record of its having been performed with success, though there are several instances of wounds in the oesophagus being healed. The operation may be rendered necessary, where obstructions of the oesophagus become so complete as to prevent the passage of nourishment into the stomach, or of air into the lungs. But it is evident, that when the obstructing cause is in the under end of the oesophagus, any incision becomes useless.

In performing the operation, the patient is to be secured in the same manner as for bronchotomy, and an incision made through the skin and cellular substance as directly opposite as possible to the part obstructed. If it be done with a view to remove an obstruction, the muscles over the trachea are to be pulled to one side, and the trachea to the other, by means of a blunt hook; by which the oesophagus will be brought into view. If the obstructed part now come in sight, the incision is to be made directly upon the obstructing body, which is to be extracted by a pair of small forceps; but if the obstruction happen to be farther down than we can with safety have access to the oesophagus, the incision is to be enlarged as much as possible, that the forceps may be able to reach and extract it. When the operation is performed, the wound will be difficult to heal,

Sore Nipples.

heal, as the sides of it will be frequently separated by the action of deglutition. On this account as great a degree of abstinence as possible is to be advised; and nothing but nourishing liquids, in small quantities, are to be allowed. The patient should be prevented from moving his neck; and the wound is to be healed as soon as possible by the same methods which are used with wounds in other parts of the body. On the other hand, if the operation has been done for the purpose of conveying nourishment into the stomach, when the patient was distressed by a tumor either in the œsophagus itself or in some of the neighbouring parts, it will be necessary to keep the wound open during the continuance of the tumor, or the life of the patient.

CHAP. XX. *Of Sore Nipples.*

WOMEN are more generally affected with sore nipples in suckling their first child than at any period afterwards. This may, in some measure, be owing to the smallness of the nipples; but very often it arises from their being unaccustomed to the irritation of sucking. In some cases, the nipples are so flat, and so much sunk in the breast, as to render it difficult for the child to lay hold of them. Here assistance can sometimes be given, by the mother pressing back the prominent part of the breast, so as to make the nipple project between two of her fingers. Should this be insufficient, the nipple may be made to project by applying to it a stout child several months old: but when this cannot be done, breast-glasses, such as fig. 68. may answer the same purpose. By applying these to the nipple, and sucking out the air, the child will commonly be enabled to lay hold of it.

The nipples at this time are liable to excoriations, cracks, or chops; which, though not attended with a formidable appearance, are frequently more distressing than large ulcers. Mild, astringent, and drying applications are most to be depended upon in such complaints; as port wine, brandy properly diluted, or lime-water; all of which ought to be applied warm. After bathing the parts with any of these, the nipple should be covered with unguentum nutritum, or Goulard's cerate; the first of which is considered as best. Even a little soft pomatum frequently rubbed upon the part, and covered with a soft linen rag, is sometimes found to give considerable relief. But the nipple should be perfectly cleared of these applications before the child is laid to the breast; and this may be done with a little port wine, or equal parts of brandy and vinegar. If proper attention be paid to these remedies, they will commonly be found to have the desired effect; but if the contrary should happen, another remains to be mentioned, which, in different instances, has given great relief: it consists in the application of a thin skin to the nipple, as the neck and part of the body of a swine's bladder with an aperture in it; which, being properly moistened and fixed to the breast, will completely protect it in the time of sucking. As long as the nipples remain any way affected, small cups of glass or tin are useful for retaining the dressings, defending the nipples from the friction of the clothes, and receiving any milk which may fall from the breast.

CHAP. XXI. *Of Paracentesis of the Thorax.*256
Fluids collected in the thorax.

WHEN either the action of the heart or of the lungs is impeded by fluids collected in the cavity of the pleura, a discharge of these fluids by a perforation is the only chance the patient has for relief. The fluids which collect in the pleura are, serum, blood, air, or pus. A collection of water or serum is frequently found in the thorax, combined with

dropsy in other parts of the body; but the affection is often local, and it is then chiefly that advantage is to be derived from an operation. Besides, in the two great cavities of the thorax, collections of water are frequently met with in the pericardium, and are said to be sometimes discovered between the layers of the anterior mediastinum. The disease is marked by the following symptoms: There is a sense of weight or oppression in the thorax, and difficulty of breathing; the patient has frequently a more uneasy sensation in one side than in the other; has sudden startings during sleep, with a sense of suffocation; is troubled with a frequent dry cough; the pulse is small and irregular; the skin dry, and the urine scanty.

With these symptoms there are commonly other marks of dropsy; and the patient sometimes, upon any sudden motion, is sensible of an undulation within the chest; and when the quantity of water is considerable, the undulation will even be heard by the bystanders, if the body be smartly agitated. For this purpose, the patient's body should be uncovered while under examination; and the surgeon should place his hand upon the breast near the sternum; then an assistant ought to raise the patient suddenly from an horizontal to an erect posture, or to stand behind the patient and make sudden jerks; when, if water be present, the undulation will be felt; but it is necessary to guard against being deceived by the noise sometimes made by the contents of the stomach.

When the water is collected in one side only, if the disease be of long standing, for the most part that side is more prominent than the other. If the water be in the pericardium, the symptoms are nearly the same as those above enumerated, with this difference, that the pain is generally felt behind, and to the left side of the sternum; and the stroke of the heart is as if buried in water, while an undulatory motion has been said to be felt opposite to the anterior extremities of the third, fourth, and fifth ribs.

In the treatment of this disease, little advantage can be derived from internal remedies. Squills, cream of tartar, mercury, and digitalis, are upon some occasions attended with advantage; but the only method from which we can expect any degree of success is the removing of the water by an operation, which should be performed as soon as there is reason to expect that danger may arise from delaying it longer. The operation is done in the same way as shall be afterwards described in the case of empyema.

Blood collected in the thorax is always extravasated thro' some wound or rupture of the vessels of the lungs or thorax. The breathing becomes oppressed, the motion of the heart and arteries feeble and irregular, and all these symptoms are more distressing than collections of other fluids. As it frequently happens, in cases of this kind, that some of the vessels of the lungs are injured, part of the blood is thrown up by coughing; which, when considerable, gives a temporary relief to the lungs and heart; and while this is the case, no operation is necessary; but whenever the action of these parts becomes much impeded by a great accumulation of blood, a perforation ought to be made to discharge it. When the extravasated blood is too firmly coagulated to pass off by a perforation, the wound ought to be made considerably larger; and if this be insufficient, injections of warm water ought to be thrown in, and allowed to remain for some time, to promote the dissolution of the mass, which is afterwards to be evacuated. If the extravasation has been occasioned by a wound in the lower part of the thorax, a new perforation will be unnecessary; an enlargement of the wound will be quite sufficient. But if it be situated in the upper part of the cavity, a perforation in the middle

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middle and lateral part of the thorax ought to be made, that the blood may be freely discharged. In case of a rib being fractured, or a vessel ruptured, the incision ought to be made as near as possible to the part affected, to allow the blood to escape, and loose pieces of bones to be removed.

The discharge of air into the cavity of the thorax produces symptoms little less alarming than those proceeding from the effusion of blood. In general they are, oppression in breathing; a tightness of the breast, attended with pain; inability to breathe in the recumbent posture; a flushing and swelling of the face; a feeble, and at last an irregular pulse: The extremities become cold, and cold sweats break out on the forehead. With these symptoms there is frequently a swelling over the external parts of the body, by air getting from the ruptured lungs into the common cellular substance; and all these complaints increasing, the patient, if not quickly relieved, soon dies; sometimes in a few hours, with marks of suffocation.

Air may be produced in the cavity of the thorax by wounds in the lungs, by mortification generating air in any of the thoracic viscera, by erosion of ulcers, by laceration in consequence of fracture in any of the bones of the thorax.

We distinguish this from other collections by the sudden oppression in breathing, by the flushing of the face, by no blood being thrown up, and by the emphysematous swelling of the chest and other parts, which has a crackling noise upon being pressed.

The treatment of this complaint consists in making small punctures in the affected part of the skin, so as to allow the air to escape from the cellular substance; and if the air shall have spread to distant parts of the body, it will escape most readily by such openings. But if this give no relief to the oppressed breathing, paracentesis ought to be performed. In former times, patients labouring under such symptoms were almost constantly left to their fate. Within these few years, however, some cases have occurred where the patients have been completely relieved by an operation being performed. This is done in the same way as in the evacuation of other fluids.

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Emphysema
or pus col-
lected in
the thorax.

Purulent matter is more frequently collected in the thorax than any other fluid: it is much more frequently formed, however, than confined there. As the matter is usually spit up as fast as it is generated, in the dissections of those who have died of this species of consumption, much extravasated pus is rarely found in the cavity of the thorax, though a great portion of the lungs be destroyed. Cases not unfrequently occur, however, which require the operation; and these may be distinguished by the following symptoms: The patient at first generally complains of a fixed pain in some part of the thorax, attended with heat, quick pulse, and other symptoms of inflammation; respiration becomes oppressed; he is unable to lie on the sound side; or, if both sides be affected, can only lie on his back; has a constant tickling cough, clammy sweats, frequent rigors or shiverings. If these symptoms be attended with an enlargement of the affected side, or with a soft œdematous fulness there, and, along with these, if there be a sensible undulation of a fluid, it may be concluded that a collection of matter is formed. The matter is commonly first formed in the substance of the lungs, and is afterwards discharged into the cavity of the pleura, though in many instances large quantities of purulent matter have been found to originate from an inflamed state of the pleura.

The operation ought to be performed as soon as there is evidence of the collection being the cause of the oppressed breathing, and that there are no signs of this being relieved by expectoration. The operation ought to be

done upon the part where the collection is supposed to be situated; and this may be known by the seat of the previous pain, and perhaps by the matter being distinguished between two of the ribs. If no matter flow, it is probably seated in the substance of the lungs; but even in this case, such an opening may be useful, by taking off the support, and giving the abscess an opportunity of bursting. If the undulation of the fluid be general, the operation is to be performed in the following manner: The patient is to be laid in an horizontal posture, with the affected side inclining a little over a table. An incision is then to be made with a scalpel through the skin and cellular substance, between the sixth and seventh ribs, and half way between the spine and sternum, from one to two inches in length, and in the direction of the ribs. The muscles are then to be cut through, keeping as near as possible to the upper edge of the inferior rib to avoid wounding the intercostal vessels and nerves. As there is no occasion for the bottom of the wound being of the same length with the external incision, it may be gradually contracted, so as at last to be only about the half. The pleura being now exposed, is to be divided by slight scratches, taking the assistance of a furrowed probe to prevent the lungs from being injured, in case they shall be found adhering to the ribs. If the contrary takes place, the fluid will rush out immediately upon a small opening being made into the cavity of the thorax; but if an adhesion appear, and if it be slight, which may be known by the introduction of a blunt probe, as much of it may probably be separated as to allow the fluid to escape. In case it be considerable, the incision is either to be continued a little nearer to the sternum, or an attempt made in some other part. After the fluid is observed to flow, it will be proper to introduce a silver canula, fig. 69. at the opening; by which means it will run more readily off, or can be more easily stopped in case the patient become faint. If the quantity of fluid be not considerable, it may generally be drawn off at once; but if it be great, partial evacuations ought to be made at different intervals, as circumstances may direct.

The canula therefore should be so formed, that by means of a strap put round the body of the patient, it can be readily secured. Its mouth is to be shut by means of a cork. A pledget of emollient ointment is to be laid over the wound; and the whole being fixed by a napkin and scapular bandage, the patient should be laid to rest. The remainder may be drawn off, probably in a day or two, or as soon as it is supposed the patient can bear it. After the fluid is carried off, the canula is to be withdrawn and the wound healed; or in case the operator be afraid of bad effects being produced upon the lungs by irritation from the canula, though of this there will be little danger, as the lungs will generally be out of its reach, the skin may be so drawn back before the first incision is made as afterwards to serve the purpose of a valve. And for some days after the operation, the incision in the integuments may be brought opposite to that in the pleura, to allow the matter to run off, or to produce a radical cure by exciting a certain degree of inflammation over the lungs and inside of the thorax.

After the matter is evacuated, the wound ought to be kept open a considerable time for the purpose of discharging the matter as fast as it is collected. If the wound be apt to heal up too soon, which will be known by the symptoms of oppression being renewed, it will be proper to keep the passage open by tents, or to introduce a bougie or silver canula a few hours occasionally, till the source of the matter be dried up; which, however, seldom happens for a considerable time, and frequently never. By attending to this circumstance, the patient may enjoy good health; where-

Paracentesis of the Abdomen, &c. as, by the neglect of it, a repetition of the first operation would soon be necessary.

CHAP. XXII. *Of Paracentesis of the Abdomen, or Tapping.*

THIS operation is an opening made into the abdomen, in order to empty any quantity of extravasated water collected in that species of dropsy called the *ascites*.

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Symptoms of a fluid in the abdomen. A fluid in the cavity of the abdomen is discovered by the swelling which it produces; by a sense of tightness in the part affected; by laborious and difficult breathing, especially when in the horizontal posture; but particularly by a sense of fluctuation being communicated to the fingers placed on one side of the abdomen, while the swelling is forcibly struck on the opposite side. There is besides much thirst, a dry skin, scantiness of urine, &c. Whatever may be the influence of diuretics and other evacuations in the cure of general dropical affections, they are rarely serviceable in local diseases of this kind, and even the operation of tapping seldom cures the distemper; but it commonly gives the patient ease for the present time, and is attended with very little pain.

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Manner of performing the operation of paracentesis. Upon the supposition that nothing forbids the extraction of the water, the manner of operating is this: Having placed the patient in an horizontal situation, as best suited to prevent fainting, and to allow the water to run freely off, the part to be perforated ought to be marked with ink; and the most approved part for the operation seems to be at a point lying at nearly an equal distance between the umbilicus and the centre of the spine of the os ilium, this being most out of the way of any of the viscera, and sufficiently depending to allow the water to escape; and as the spleen is less frequently enlarged than the liver, the left side is generally preferred. Various means have been used for applying an equal pressure in this operation. Some apply pressure by the hands of assistants; others use a broad piece of flannel, or other kinds of cloth, slit a certain way from each end; then the ends are drawn by assistants till sufficient pressure is made. Broad belts are used by some practitioners; but one of the best contrivances for this purpose is the bandage invented by the late Dr Monro, (fig. 70.) Till very lately, a puncture was first made with a lancet, then a trocar of a round form (fig. 71.), and with a triangular point, was constantly used: but the entrance of this instrument being always attended with difficulty and pain, a flat trocar is now very frequently employed; and that invented by Mr Andree (fig. 72.) seems the best which has yet appeared. The bandage being now applied and drawn a little tight, the part to be punctured is to project a little over the edge of the bed. The operator fixes the head of the trocar in the palm, while the fore finger directs the point of the instrument. He is then to push it forwards till he is satisfied, by the want of resistance, that the end of the canula has reached the cavity of the abdomen. The perforator is now to be withdrawn, and the water allowed to flow as long as any of it can be taken off, the bandage being from time to time pulled to favour the discharge. But if the patient become faint, a stop for a few minutes should be put to the discharge every now and then, by placing the point of the finger upon the mouth of the canula. If any of the viscera happen to stop the flow of the water before the swelling is much diminished, a blunt probe is to be introduced, but bent at the end, lest it slip into the cavity of the abdomen. When the serum is thick and gelatinous, it may sometimes be necessary to introduce a larger trocar than the one first employed. When the water does

not flow, because it is collected into cysts, the canula is to be withdrawn, and the wound covered with a pledget of simple ointment. The operation may then be renewed immediately, or on the following day, upon the opposite side of the abdomen, or in the most depending part of the tumor, in whatever part of the abdomen it may be placed.

During the operation it is necessary to keep up a pressure on the abdomen, otherwise the patient will be apt to fall into faintings from the weight on the great vessels of the abdomen being taken off, and the sinking of the diaphragm succeeding, in consequence of which more blood flows into the inferior vessels than usual, the superior ones are left too empty, and thus the regular progress of the circulation is interrupted. To obviate this, the pressure must not only be made during the operation, but be afterwards continued. As to the dressing, it has been already mentioned, that the wound may be covered with a pledget of simple ointment; but between the skin and the roller some recommend a piece of flannel dipped in brandy or spirit of wine to be applied. The bandaging in this manner may even have some effect in preventing a return of the disorder. When the water again collects, the operation should be repeated whenever the swelling has acquired a considerable size: and though this operation does not always effect an absolute cure, yet it sometimes preserves life a great many years, and even a comfortable one, especially if the waters have been long collected.

After the operation, practitioners advise the abdomen to be frequently rubbed with astringent spirituous applications. This cannot be done for the first two days after the operation, as it would then be improper to remove the bandages; but after that time, they may be removed daily, for about a quarter of an hour; and camphorated spirit of wine, or other applications which may have a similar effect, may be applied with strong friction over the abdomen, the body being kept, during this period, in the horizontal situation, and the bandage applied immediately after the friction is finished.

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Sometimes, instead of water, we find air contained in the abdomen; and the inflation is of two kinds: First, that in which the air is contained in the intestines; in which case the patient has frequent explosions of wind, with a swelling of the belly frequently unequal. Secondly, where the air is collected in the cavity of the abdomen; and here the swelling is more equal, without any considerable emission of air. In both varieties of the disease the swelling is more tense than where water is contained, and the belly sounds when struck, and affords to the touch and pressure nearly the same sensation as is received from a bladder filled with air. Of these two disorders the former is by much the most common. Many extensive practitioners have never met with an instance of true abdominal tympanites. A few well authenticated cases, however, have occurred, where the air was collected between the containing and contained parts of the abdomen. In some of them the air was found to have escaped by a small hole in the intestines, from which it has been supposed that the other cases were of the same nature. When the symptoms become urgent, there is as much necessity for discharging the air as for drawing off the water in cases of dropsy. The pressure and perforation are to be made in the same manner as directed for ascites, with this difference only, that a trocar of the very smallest size ought to be used; for by it the air can be as easily discharged, and the wound will heal more readily than when a large opening is made. After the air has been extracted, the treatment ought to be nearly the same as that recommended in cases of ascites.

CHAP. XXIII. Of Hernia.

SECT. I. Of Hernia in general.

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Definition
of a hernia.

THE name of *hernia* might with propriety be applied to every swelling occasioned by the dislodgment of parts from those boundaries within which, in a state of health, they are contained; but the general acceptation of the term implies a tumor produced by the protrusion of some part or parts from the cavity of the abdomen.

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Situation
and con-
tents of her-
nia.

The parts in which hernia usually appear are the groin, scrotum, labia pudendi, the upper and fore part of the thigh, the umbilicus, and different points between the interstices of the abdominal muscles. If the situation of such tumors be various, the viscera which produce them are still more so; instances having occurred of the stomach, uterus, liver, spleen, and bladder, being found to form their contents. But a part of the intestinal canal, or a portion of the omentum, are from experience known to be the most frequent cause of their formation.

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Their dif-
ferent
names.

From these circumstances of situation and contents, all the different appellations are derived by which hernia are distinguished. Thus they are termed *inguinal*, *scrotal*, *femoral*, *umbilical*, and *ventral*; from their appearing in the groin, scrotum, thigh, navel, or belly. When the tumor is confined to the groin, the hernia is said to be incomplete, and is termed *bubonocoele*; but when the swelling reaches down to the bottom of the scrotum, the rupture is then supposed to be complete, and the disease obtains the name of *scrotal rupture*, or *eschiocele*.

Of these disorders the inguinal hernia is by much the most frequent; next to that is the femoral. The umbilical is seldom observed in men, or even in women who have not born children.

The causes which tend to the production of hernia in its more usual form are these:

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Causes
which pro-
duce them.

I. The containing parts of the abdomen we know to be elastic and compressible; whatever, therefore, tends to produce a diminution of capacity in the cavity of the abdomen, must occasion a proportional degree of risk of some of the contained parts being pushed from their natural situations. Violent coughing, crying, laughter, or great bodily exertion, are attended with more or less contraction of the abdominal muscles, and particularly of the diaphragm; and as the contraction of these muscles must always diminish the abdominal cavity, these causes therefore are frequently found to be productive of hernia.

II. Falls, in consequence of the derangement they produce in the abdominal viscera, from the sudden and violent shock with which they are often attended, are not unfrequently the immediate causes of hernia.

III. Persons of a preternatural laxity of frame are very liable to hernia. The containing parts of the abdomen, from the want of a sufficient tone and firmness, are unable in such people to resist on all occasions the weight of the different viscera; and they are therefore more particularly exposed to disorders of this kind on the slightest application of any of the causes already mentioned.

IV. Sprains are apt to induce a laxity of the part injured; and have therefore a similar influence in inducing hernia with general laxity.

V. It has been observed that the people of those countries where oil is much used as an article of diet, are particularly liable to hernia.

In whatever parts the parietes of the abdomen happen to be weakest, these various causes will most readily operate in producing hernia; and accordingly we find, that descents of the bowels usually occur only in such parts.

In whatever situation a protrusion of any portion of the intestines occurs, except in the case of the *heraia congenita*, as all the viscera are contained within the peritonæum, a portion of that membrane, it is evident, must be carried down together with the parts protruded; and in every such instance, it is this portion of the peritonæum which goes down along with the gut, that is termed the *hernial sac*. The size of this sac is various in different subjects, and in different stages of the same disorder. On the first appearance of the disease, it is commonly of no very considerable size, as such swellings seldom acquire any great bulk at once: but by repeated descents of the bowels, it comes to be pushed lower and lower, till in some instances its bulk becomes very considerable indeed; and when in this advanced period of the disorder the sac happens to be laid open, it is found to contain either large quantities of omentum or intestine, and frequently large portions of each. As the peritonæum has this property in common with many other parts of the body, of thickening according to the degree of any gradual extension applied to it, so in many instances the thickness and firmness of the hernial sac are often really astonishing.

All the bad symptoms which are found to occur in hernia, proceed, as may be readily supposed, either from obstruction to the passage of the feces when the intestinal canal forms the tumor, or from a stoppage of circulation occasioned by stricture on the prolapsed parts: so that the attending symptoms, it is evident, will be always more or less hazardous according to the nature of the parts so protruded.

Thus, when omentum alone forms the substance of hernial swellings, as that organ does not appear to be so immediately necessary for life as many of the other viscera, such tumors accordingly are not so frequently productive of bad consequences, at least they are seldom in any degree so hazardous as when a part of the alimentary canal is either protruded by itself or along with omentum.

Although this, however, is in general the case, yet it does sometimes happen, that even an omental rupture is productive of no small degree of danger. When a stricture so complete upon it occurs as to occasion a stoppage of circulation in the protruded part, mortification with all its bad consequences must be the certain event: And besides, the connection between the omentum, stomach, and other viscera, is such, that a sudden descent of any considerable portion of the former sometimes brings on vomiting, hickup, and other troublesome symptoms: And lastly, although a rupture containing omentum only might not of itself produce any thing bad; yet as the passage through which the omentum has slipped must of necessity continue open so long as that viscus remains protruded, and as that circumstance alone must, so long as it continues, render it more easy for a portion of gut likewise to get down, this of itself is a sufficient reason for intitling even this species of hernia to the serious attention of practitioners.

But whatever the contents of such swellings may be, as their remaining in some instances for a considerable length of time without being productive of any bad symptoms, must proceed entirely from the circulation continuing to go freely on, notwithstanding the derangement of parts; so, whenever a stricture occurs up the protruded viscera, sufficient to produce either a stoppage of the circulation, or of the fecal contents of the alimentary canal, when a portion of gut forms the disease, the following in general are the symptoms which accrue.

An elastic colourless swelling is observed at the part affected; a slight pain is felt not only in the swelling itself, but, if part of the alimentary canal is down, an universal uneasiness.

Hernia in
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nial sac.271
Cause of
the bad
symptoms
which ap-
pear in her-
nia.

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Enumera-
tion of
these symp-
toms.

Hernia in general. easiness is perceived over the whole abdomen; and this pain is always rendered worse by coughing, sneezing, or any violent exertion. The patient complains of nausea; frequent retching; can get no discharge by stool; becomes hot and restless; and the pulse is commonly found quick and hard. When the swelling is formed entirely by a portion of gut, if no faeces be contained in it, it has a smooth, equal surface; and is easily compressible, but instantly returns to its former size on the pressure being removed: but, in gut-ruptures of long standing, where hard faeces have collected in the protruded bowels, considerable inequalities are detected. When again the tumor is composed both of gut and omentum, its appearance is always unequal, it feels soft and somewhat like dough, and of course is not so elastic as when part of the intestinal tube only is down; for although, like the other, it is compressible, it does not so readily regain its former dimensions on the pressure being taken off.

273 Never happen in omental hernia. It will be readily supposed, that the symptoms we have described never can happen from the presence of omentum only: For although stricture produced on a portion of omentum, even when no part of the intestinal tube is down, does now and then occasion a good deal of distress, such as pain in the part, sickness, vomiting, and twitching pains through the whole belly; yet no obstruction of the gut ever occurs from this, and of course none of the symptoms ever prove so alarming as when any part of gut is affected. If these symptoms we have described as being produced by a strangulated gut, are not now obviated by a removal of the stricture which produced them, the nausea and retching terminate in frequent vomitings, first of a bilious, and afterwards of a more fetid matter; the belly becomes tense; the pain turns more violent; a distressing convulsive hiccup comes on; the fever, which before was not apparently of much consequence, now becomes very formidable; and a total want of rest, with a very disagreeable state of anxiety, continues through the whole course of the complaint. — These symptoms having gone on with violence for some time, the patient is at last commonly relieved in a sudden from all manner of pain; and then he flatters himself that all danger is over. But instead of that, the pulse, from having been hard and frequent, becomes languid and interrupted; cold sweat breaks out over the whole body, but especially on the extremities; the eyes acquire a kind of languor; the tenseness of the abdomen subsides, and the swelling of the part affected disappears; the teguments covering the parts, which before were either of a natural appearance, or had somewhat of a reddish inflamed cast, now acquire a livid hue, and a windy crepitous feel is distinguishable all over the course of the swelling. If the protruded parts have not of themselves gone entirely up, their return is now in general easily effected by a small degree of pressure, and the patient then discharges freely by stool; but the cold sweats increasing, the hiccup turns more violent, and death itself is at last ushered in by its usual forerunners, subultus tendinum, and other convulsive twitchings.

These are the ordinary symptoms of what is termed a *strangulated or incarcerated gut-hernia*: that is, when the parts protruded become so affected by stricture as to produce pain; and do not either return to their natural situations on the patient's getting into a horizontal posture, or cannot even be immediately replaced by the hands of a practitioner.

275 Cure. In whatever situation a strangulated hernia occurs, the only rational method of cure, it is evident, must consist in the removal of that stricture which prevents the return of the protruded parts. It is that stricture which ought to be considered as the cause of all the mischief; and unless it

be removed, nothing effectual can be done for the relief of *Hernia in general.* the patient.

Various methods have been attempted by practitioners for the removal of stricture in these disorders; all of which may be comprehended under two general heads.

I. Such as effect a reduction of the protruded parts, without the interposition of incision or any chirurgical operation properly so called; and,

II. A division of the parts producing the stricture, so as to admit of a replacement of the deranged viscera, constituting what is termed the *operation for the hernia*.

The remedies to be employed for accomplishing the first of these are, a proper posture of the patient, with the manual assistance of a practitioner; blood-letting, stimulating clysters, opiates, the warm bath, and proper applications to the tumor itself. — If these fail, there is then no other means of cure left but the operation of dividing the integuments, and replacing the viscera.

As soon as the assistance of a practitioner is desired for the removal of symptoms in cases of hernia, the first circumstance requiring his attention is the placing of his patient in such a posture as will most probably favour the return of the protruded parts. Placing the patient's feet over the shoulders of another person, while his body is allowed to hang downwards, and causing him to be a good deal jolted about, has on some occasions answered when other means have failed.

276 Method of reducing the intestine. The surgeon should at the same time endeavour to assist the return of the bowels, by means of gentle pressure with his hands and fingers. In the inguinal or scrotal hernia, this pressure should be made obliquely upwards and outwards to correspond with the opening in the external oblique muscle; in the femoral hernia it ought to be made directly upwards; in the umbilical and ventral hernia directly backwards. — The swelling should be grasped with one hand at the bottom, while with the fingers of the other hand an attempt is made to push gently the contents of the tumor into their place, always observing that the parts last protruded be first reduced. This operation is by authors termed the *taxis*.

When the means now mentioned have failed, no remedy affords more relief than blood-letting. The quantity to be drawn ought chiefly to be determined by the strength of the patient. There is scarcely any disease, however, where such large quantities of blood can with propriety be taken from weak people. Bleeding till the patient is in a state of deliquium animi, is frequently known to produce a more effectual relaxation of the muscles than can be done by any other means. On that account it is sometimes advised in cases of hernia, and the practice is now and then attended with advantage.

As an obstinate costiveness is commonly one of the most alarming symptoms of hernia, it has been a common practice to exhibit a variety of stimulating purgatives both by the mouth and anus; but they are very seldom of much service, and in that case almost universally do injury, by increasing not only the sickness at stomach, but the tension and pain of the tumor. When they are to be employed, they ought to be thrown up by the anus. For this purpose aloes and other stimulating substances, but particularly tobacco-smoke, are employed; and although this last remedy, which is to be thrown in by double bellows, &c. does not always act as a purgative, it may be usefully employed as an anodyne. Where an evacuation by stool is wanted, it may in general be readily procured by the injection of warm water, in which a little Castile soap is dissolved, in the proportion of a drachm or a drachm and a half of the latter to a pound of the former. Warm bathing is another remedy greatly extolled, either by general immersion or local application, by

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general.

by means of warm water put into ox-bladders covered with flannel, and laid across the abdomen.

To diminish the size of the tumor, remedies of an opposite quality from these have been used; and though by some this practice has been considered as hazardous, yet by others, particularly by the late Dr Monro and Mr Benjamin Bell, more advantage has been found from cooling applications than from those of a different nature. Snow, ice, or cloths dipped in a recent solution of sal ammoniac in water and vinegar, or cold saturnine applications, or cold water and vinegar, have been employed with advantage. If, notwithstanding these remedies, the disease becomes worse, and no probability remains of success, the division of the parts producing the stricture can alone save the life of the patient.

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When the
operation
for redu-
cing the
intestine
should be
performed.

To determine the exact time at which to proceed to an operation, has been considered as one of the nicest points in surgery. In general, when every attempt has failed, and no repetition of the former remedies is likely to succeed, the surgeon ought certainly to proceed to the operation. A few hours, even when assistance has been early applied, is perhaps all the time which ought ever to be consumed in trials of this nature. But however necessary this operation may be when a patient's life is in danger, as it is always attended with some degree of hazard, it ought never to be practised where symptoms of strangulation do not exist.

In that kind of hernia called *chronic*, the circulation of the part forming the hernia, as well as the peristaltic motion of such parts of the alimentary canal as have been protruded, go freely and regularly on. There are many instances of large hernia falling down even to the bottom of the scrotum, and continuing there for many years, without producing any interruption to the usual discharge by stool. All that can be done here is, to prevent any accumulation of feces in the intestine, by prescribing a proper diet, and the occasional use of gentle laxatives; and obviating any inconvenience which might arise from the weight of the tumor, by the application of a proper truss or suspensory bandage; to warn them of the risk to which they are constantly liable, and to caution them against violent exercise, particularly leaping, and every sudden exertion. The truss ought to be fitted exactly to the part for which it is intended, for without the utmost nicety in this respect, it must always do more harm than good: for the sole purpose of a bandage, in cases of hernia, is to prevent effectually the falling down of such parts as have been newly replaced. If therefore the pad or bolster of the bandage does not bear properly against the opening upon which it is placed, a portion of gut may slip out, and be materially injured by the pressure of the pad. Fig. 74. represents a truss for an inguinal or femoral hernia of one side, fig. 75. a truss for the same disease in both sides, and fig. 76. a truss for an umbilical hernia.

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Method of
perform-
ing it.

We shall now proceed to describe the circumstances to be attended to in performing the operation for hernia in general. A table of convenient size and height being placed in a proper light, the patient must be so laid on it as to relax the diseased parts as much as possible, and then secured by proper assistance. To lessen the contents of the abdomen as much as possible, the bladder ought to be emptied previous to the operation. An incision is to be made with a common round-edged scalpel through the skin and part of the cellular substance, long enough to allow the stricture to be fully exposed. The rest of the cellular substance is then to be divided with the greatest attention. That part of the muscle forming the stricture or ring must next be laid distinctly in view. A small portion of the protruding sac must also be exposed; after which the directory (fig. 77.)

is to be passed between the ring and the sac. A straight probe-pointed scalpel is now to be introduced into the groove of the directory, and by it the ring is to be dilated till the point of the finger can be introduced. The finger is here considered as the safest director; for it being insinuated into the aperture in the tendon immediately above the protruded parts, the point of the knife is easily introduced upon it; and by keeping the end of the finger always a little before the knife, the opening may be enlarged to any necessary extent without risk of wounding any of the contiguous parts.

By the ease with which the finger is introduced, the operator will be enabled to judge when the ring is sufficiently dilated; and if the strangulation was entirely in the ring, it will now be evident that every obstacle to the reduction must be removed, and of consequence that the prolapsed parts may be returned with little difficulty. If the patient be young, or if the disease has continued a considerable time, such a degree of inflammation frequently ensues in the neck of the sac as to produce thickening and straitness; so that, after the sac and its contents have been entirely freed from the stricture of the ring, the intestines cannot be reduced. We judge this to be the case when, after the stricture of the ring has been removed, the parts prolapsed do not expand into their natural size, and farther, when they make resistance when we attempt to return them. In this case, the neck of the sac must be opened with the utmost caution, to avoid wounding the parts within it.

If the herniary sac, under the straitened place of its neck, be thin and transparent, and there is little or no reason to suspect an adhesion of the bowels to the sac, the best method, as Dr Monro, in his publication on the *Bursæ Mucosæ*, observes, will be to make a small hole in the sac below the stricture, and then to introduce a small furrowed probe, and to cut cautiously upon it. But if the sac be thick and dark coloured, and there is likewise a suspicion that the bowels may adhere to it, the easiest and safest manner will be to make the hole in the peritoneum above the stricture; then to introduce a common probe, bent near its point into a semicircle, with its point directed downwards through the stricture into the sac; and upon the point of it to make, with great caution, another small hole; after which we may either cut upon the probe, or introduce a furrowed probe, and divide the neck of the sac.

After this, the bowels are to be returned by pressure upon the sac, without opening it farther; and the sides of the wound in the skin are to be brought together, and kept so by means of slips of adhesive plaster, though stitches made at the distance of a finger-breadth from each other will exclude the air, and prevent the return of the bowels more effectually. Over these are to be laid several folds of charpie, and the whole is to be secured by a bandage adapted to the nature of the part.

The patient, upon being carried to bed, should be so placed as to have the part upon which the operation was performed higher than the rest of his body, or at least as high as the situation of the part operated upon will allow, in order to prevent a return of the disease. After the operation, opiates are particularly useful, and ought to be repeated as circumstances may require. It is likewise necessary that the patient be kept cool. In plethoric habits, blood-letting is proper, together with a rigid attention to low diet. A frequent use of clysters and gentle laxatives, to keep the belly moderately open, ought not to be neglected. When the constitution has been previously much reduced, instead of blood-letting and a low diet, a nourishing regimen is necessary. The dressings ought not to be removed till the third or fourth day after the operation, when the sides

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Treatment
afterwards.

Hernia in general. sides of the wound will be found almost adhering together; and it attention be paid to the subsequent treatment, the sore will be generally healed in two or three weeks. As soon as the wound is firmly cicatrized, a truss ought to be properly fitted to the part, and should never, on any future period of life, be laid aside.

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Method of performing the operation when adhesions or mortifications have taken place. When the hernia is of long standing, and when there is reason to think adhesions have taken place between the sac and bowels, or that mortification has already begun, or that some filaments run across the sac and prevent the reduction, or that there is water in the sac, or that the gut is in danger of being entangled from a part of the omentum being down, a different method of operating becomes necessary.

The patient is to be placed as already directed. The operator is to grasp the tumor with the one hand, so as to make the skin tense on the fore part of it, while with the scalpel in the other he divides the skin from one end of the tumor to the other. The cellular substance is by gentle strokes to be divided, till not only the ring, but the whole length of the sac, is laid bare. An opening is now, in the most cautious manner, to be made into the sac by slight scratches, to avoid hurting any of its contents.

In making this perforation, which is considered as the nicest part of the operation, considerable assistance is obtained from the use of the small directory, upon the point of which the fibres of the sac are to be successively raised and divided till an opening is made. The opening is to be enlarged till it admit the fore-finger of the left hand, which serves as a directory for conducting the straight probe-pointed scalpel with which the sac is to be divided through its whole length.

The sac being laid fully open, the parts contained in it ought to be examined with the nicest attention, to discover whether they are all sound or not; and if, upon an attentive inspection, it is found that they are not evidently in a gangrenous state, even although they seem considerably inflamed, they should be immediately returned into the abdomen. When adhesions take place between different parts of the protruded gut, the greatest caution is necessary in separating them. When one part of a gut adheres so firmly to another as not to be separated but with difficulty, it is much better to return the whole, even in that state, into the abdomen, than to run the risk of hurting the intestine materially by using much force. When adhesions occur between the hernial sac and the gut, or between the gut and omentum, if the filaments producing the connection cannot be otherwise removed, as there is no great hazard in wounding the omentum, and still less in hurting the sac, a very small portion of these may be dissected, and returned with the gut into the abdomen. When the bowels cannot be reduced with ease, the ring is to be dilated by the blunt-pointed scalpel in the manner already directed. After returning the contents of the sac into the cavity of the abdomen, it has been proposed by some authors to pass a ligature round the neck of the sac, with a view of procuring a reunion of its sides, so as to prevent a future descent of the bowels; and various other methods, even actual and potential cauteries, have been proposed: but as none of them yet attempted have been found sufficiently to answer the purpose, the only thing that can be recommended is a well made truss.

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Treatment when the bowels are in a state of gangrene. When the bowels are actually in a state of gangrene, as the returning of such mortified parts might be attended with the very worst consequences, a great degree of caution is necessary. When the omentum is found in a mortified state, as the excision of a portion of this substance is not attended with much risk, it is the common practice to cut away the diseased parts, and to obviate any inconvenience which might ensue from the hemorrhagy. We are advised to make

Hernia in general. a ligature on the sound parts previous to the removal of those which are mortified; whilst the ends of the ligature being left hanging out of the wound, the surgeon has it in his power to remove them when circumstances appear to render it proper. These ligatures on the omentum, however, are frequently productive of bad consequences. No hemorrhagy of any importance ever occurs from a division of this membrane, even in a sound unmortified state; such parts as have become gangrenous may therefore be freely cut off, and the remaining sound parts be afterwards, without the intervention of ligatures, safely introduced into the abdomen. If a vessel of any size in the omentum has been divided, a ligature may be passed above the vessel itself, and the ends left hanging out of the wound; the threads may be afterwards pulled away at pleasure. When a rupture has been of long duration, it sometimes happens, that from the pressure made by the truss, and other circumstances, portions of the omentum are collected together into hard lumps. If these be small, they may be returned into the abdomen without producing any inconvenience; but if from their bulk and hardness they are likely to do mischief, they ought to be cut off. When part of the omentum is to be removed, it ought to be previously expanded and divided with scissars, which will be more convenient than any other instrument. When again a small portion of gut is found mortified, we are to endeavour, by means of a needle-ligature, to connect the sound part of the gut immediately above the mortified spot to the wound in the abdomen already made. By this means, when the mortified part separates, or perhaps what is better, when it has been immediately cut out, the fæces are discharged by the wound; and there are different instances where, after such a discharge has continued for some time, the wound has entirely healed.

But when the mortified portion of gut is of considerable extent, and includes the whole circumference of the intestine, all that can be done is to remove it, and to draw, by means of a ligature, the upper end of the gut towards the under, and afterwards connect them to the inner edges of the wound. This at least affords a chance of the ends of the gut being brought to reunite; and if unfortunately that event should not take place, a passage of the fæces will still be secured. All such mortified parts as are to be removed ought to be cut off, and the remaining sound intestine retained, before the opening in the ring can be dilated with safety, lest the gangrenous portion slip in together with the sound. The parts forming a hernia being all completely replaced, when the sac in which they were contained is found thick, hard, and much enlarged, as in such a state no good suppuration can take place, and as its preservation cannot be in any degree useful, such parts of it as can be cut away with propriety ought to be removed. All the lateral and fore parts of the sac may be cut off with safety; but as it is commonly firmly connected with the spermatic vessels behind, this part of it ought not to be touched.

SECT. II. Of Bubonocèle, or Inguinal and Scrotal Hernia.

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Symptoms This species of hernia is formed by a protrusion of some of the abdominal bowels through the rings of the external oblique muscles. It is known by the general symptoms of *bubonocèle* hernia already enumerated, and by a soft and somewhat elastic swelling, beginning in the groin, and descending by degrees into the scrotum in men, and into the labia pudendi in women. When the hernia contains omentum only, the swelling is both more soft, compressible, and more unequal than when the gut alone is down; the scrotum becomes more oblong than in the intestinal hernia; and when the quantity of omentum is large, it is also much more weighty than a gut rupture of the same size; but frequently the tu-

Bubonocoele
or Inguinal
and Scrotal
Hernia.

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diseases.

mor is composed of both gut and omentum, and then the distinguishing symptoms of each can never be so clearly marked.

Bubonocoele may be confounded with certain other diseases; but may be distinguished by the following marks which are present in these disorders, while the symptoms of hernia are absent: From venereal bubo, by the presence of that incompressible hardness with which all such swellings are at first attended, and by the fluidity of matter which in the suppurative state is always observable: From hernia humeralis, or swelling of the testes, by the absence of the hardened and enlarged state of the testis and epididymus, and likewise of the pain, the tumor of the testicle being remarkably heavy in proportion to the bulk, the spermatic process being commonly free from the swelling. In the hernia humeralis also the intestines are unobstructed, and the general symptoms of hernia are wanting. From the hydrocele of the tunica vaginalis testis, by the tumor generally feeling more smooth to the touch than in hernia, by the swelling here beginning in the under part of the scrotum and ascending, by the spermatic cord being always free and distinct, and by a fluctuation being evident. From hydrocele of the spermatic cord, sometimes with much difficulty, and therefore it requires here particular attention. In every case of tumor in the testes, where the most perfect certainty is not obtained, and when it is necessary to have recourse to an operation, the surgeon ought to proceed as in a case of real hernia.

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Treatment.

The treatment of bubonocoele is the same with that already advised in the treatment of hernia in general, only making allowance for the situation of the disease. In attempting the reduction by means of the hand, the pressure should be obliquely upwards and outwards, corresponding with the ring of the abdominal muscle. In performing the operation, the patient should be laid on a table, with his head and body almost horizontal, whilst at the same time his buttocks are somewhat elevated by pillows placed beneath them. The legs hanging over the edge of the table ought to be separated, so as to admit the operator between them; and should in that situation be firmly secured by an assistant on each side, who should take care to keep the thighs so far raised as to relax all the abdominal muscles. The parts being previously shaved, an incision must be made with a common round-edged scalpel through the skin and part of the cellular substance, beginning at least an inch above the superior end of the tumor, and continuing it down to between two and three inches below the ring.

Although in by much the greatest proportion of hernial swellings the spermatic vessels lie behind the protruded parts, yet on some occasions they have been found on the anterior part of the tumor; so that in order to avoid the risk of wounding them, as soon as the skin is divided, the remainder of the operation ought to be done in the most cautious manner, care being taken to avoid every large blood-vessel which makes its appearance. The ring must now be laid distinctly in view; a small portion of the protruding sac must also be exposed; after which the director is to be introduced between the ring and the sac, placing the point of the instrument obliquely upwards and outwards. A blunt pointed bistoury is now to be introduced into the groove of the director, and by it the ring is to be dilated till the point of the finger can be introduced. The director is now to be laid aside, and the finger used in place of it through the rest of the operation. After the operation is finished, the dressings are to be applied, and the whole secured by a T bandage, or suspensory bag, properly stuffed with soft lint.

The patient, on being carried to bed, should have a pillow under the buttocks, to elevate them a little above the rest

of the body, and should be treated in the manner which has been already directed. As soon as the wound is firmly cicatrized, a truss ought to be properly fitted and used through the rest of the person's life. Females are liable to this species of rupture as well as men; and as the opening in the external oblique muscles is exceedingly similar in both sexes, the treatment of this species of hernia in females is very similar to what is found to answer in men. When clysters, blood-letting, and the other remedies formerly enumerated, fail, the same operation of enlarging the opening in the tendon of the oblique muscle is here equally proper as in the other sex.

As modest women are apt to conceal disorders of this kind, they may frequently happen when the surgeon receives no information about them. Whenever, therefore, such symptoms of colic occur as give reason to suspect the existence of hernia, a particular examination ought always to be made, in order, if possible, to detect the cause of the mischief, from the removal of which alone a cure can be expected.

SECT. III. Of Hernia Congenita.

THE testes in the foetus are, till near the time of delivery, lodged in the cavity of the abdomen. When they descend into the scrotum, they push before them a portion of the peritonæum, which afterwards forms the vaginal coat. The passages by which they descend are soon shut up; but sometimes the contrary happens, and then a portion of some of the abdominal viscera passing down, forms that species of hernia to which new-born infants are liable, termed by Haller the *hernia congenita*. The testicle and protruded intestine being here in contact with one another, the tunica vaginalis testis forms the hernial sac.

It has been affirmed by some of the latest writers, that hernia congenita cannot be distinguished from that contained in the common herniary sac; and that though there was a distinction, it could be of no material use in practice. But Dr Monro observes, that a hernia congenita may be distinguished in an adult by an evident external mark; which is, that the bowels push down between the sac and the forepart and sides of the testicle, so as often in a great measure to conceal it; whereas, in the common hernia, every part of the testicle can be felt distinctly: And that it is of material use to make the distinction; because in whatever manner we operate in hernia congenita, unless we take the utmost care to exclude the air, there will be a more violent inflammation and greater distress than in common cases, because the testicle will partake of the inflammation.

In the treatment of ruptures of the congenital kind, little difference occurs from the management of the common scrotal hernia; only a truss ought never to be applied to infants, unless the testicle can be felt in the scrotum, after the contents of the hernia have been reduced; as it would entirely prevent the descent of the testicle, which yet remains in the abdomen. If any operation has been performed, the testicle should, immediately after the bowels are reduced, be covered with the vaginal coat, and at each dressing care should be taken that the air be excluded. In every other respect the treatment of congenita hernia is the same with that of hernia in general.

SECT. IV. Of Femoral or Crural Hernia.

THE seat of this species of hernia is upon the upper and fore part of the thigh; the protruded bowels passing out at the same opening through which the large blood-vessels of the thigh are transmitted from the abdomen, and of consequence under that part of the tendon at the under end of the abdomen known by the name of *Poupart's* or *Fallopian's* ligament. Sometimes the bowels which protrude are situated

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or Crural
Hernia.

immediately over the femoral vessels, sometimes on the outside of these, but more frequently they lie upon their inner side. The disease is more frequent in women than in men, on account of the width of the female pelvis, and of consequence the length and laxity of the ligament. The femoral hernia is more in danger of being confounded with inguinal hernia than with any other; the tumor, however, is deeper, and the ring of the abdominal muscles, which lies entirely above the tumor in femoral hernia, completely surrounds the parts in that of the inguinal kind.

288 Treatment. In the treatment of femoral hernia, when symptoms of strangulation occur, we must use all the remedies commonly practised for hernia in general; only that here, in attempting to reduce the parts by the hand, the pressure should be made directly upwards. An incision of sufficient length is to be made through the integuments, so as to allow that part of the tendon which forms the stricture to be laid fairly in view; and after dividing the integuments, we are cautiously to cut the fascia lata of the thigh, and separate any glands which may come in the way till the stricture and part of the sac distinctly appear. The stricture is then to be divided, by cutting fibre after fibre successively. The spermatic vessels in the male, or round ligament in the uterus in the female, may be avoided by cutting in a direction towards the umbilicus, carefully dividing the tendon transversely. Some authors, from a sense of the danger attending this part of the operation, have recommended merely to dilate the passage, instead of dividing the tendon; but in such a situation, to attempt a farther dilatation without the assistance of the knife, would probably be seldom attended with any advantage. After the parts are reduced, the wound is to be dressed as directed in the treatment of hernia in general: a piece of thin leather spread with some adhesive plaster retains the dressings better, and with much more ease, than any other bandage.

SECT. V. Of other Species of Hernia.

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los, or um-
bilical her-
nia.

In umbilical hernia the parts protruded pass out at the umbilicus, and are commonly the intestines, or omentum, or both; sometimes part of the stomach, the liver, and even the spleen, have been found in the sac. Here, as in other ruptures, the peritonæum forms the sac, and in recent cases it is generally very evident; but by the size of its contents, or a long continuance of the disorder, it sometimes becomes so connected with the surrounding parts, that by many its existence has been doubted, and sometimes the swelling has increased to such a degree as to burst even the skin itself. The disease occurs most frequently in infancy, soon after birth. In the adult state corpulent people are more subject to it than those of a contrary habit; and pregnant women are particularly subject to it, on account of the size of the uterus. The diagnosis in this disease is readily made, as the disorder can scarcely be confounded with any other. If the disease be attended to in due time, a bandage properly fitted will generally effect a cure; and in such swellings as occur in pregnancy, delivery will commonly remove the disorder; but even in cases of pregnant women, a bandage early applied and properly used will give considerable relief, till a cure can be obtained by delivery. In this disease the omentum is more frequently pushed out than any other viscous; hence umbilical hernia in general are not productive of such bad symptoms as usually occur in the other kinds of rupture. When, however, the intestines protrude, the usual symptoms of a strangulated hernia are apt to be induced; and when the means usually employed for returning the gut into the abdomen do not succeed, a cure it is evident must depend entirely on a thorough removal of the stricture. In performing this operation, an incision through the integu-

ments is the first step to be taken, so as to expose the stricture of the tendon and the neck of the sac. The stricture is to be removed in the manner already described; and as the tendon completely surrounds the neck of the sac, the stricture may be cut wherever it can be most readily dilated. A radical cure similar to that for the other species has been proposed, but with as little probability of success.

Ventral rupture is a protrusion of some of the bowels through the interstices of the abdominal muscles, and is most frequently observed in some of the parts most contiguous to the linea alba. The treatment of this species of disease is exactly the same with that of exomphalos.

Hernia of the bladder of urine, though less frequent than that of the omentum or intestines, is not very uncommon. The situation in which it occurs is in the groin, through the abdominal ring, in the fore part of the thigh, under Poupart's ligament, so as to form inguinal or crural hernia. Instances have likewise occurred of the bladder being pushed into the perinæum. Sometimes it occurs by itself, without any complication; at other times it is accompanied with intestines and omentum, both in inguinal and femoral hernia: when complicated with bubonocoele, the protruded part of the bladder is situated between the intestine and spermatic cord.

The usual symptoms are a tumor, attended with fluctuation either in the groin, in the fore part of the thigh, or perinæum, which generally subsides when the patient voids urine. When the swelling is large, before water can be made with freedom, it is commonly necessary to have recourse to pressure, at the same time that the tumor, when in the groin or thigh, is as much elevated as possible; but when the swelling is small, and especially when no stricture is as yet produced, the patient generally makes water with great ease, and without any assistance from external pressure. When the disease occurs without any complication, it is commonly owing to a suppression of urine. In the diagnosis care ought to be taken not to mistake it for a hydrocele. In recent cases, the part protruding may in general be easily reduced, especially if we attend to the suppression of urine, which probably gave rise to the disease. A proper truss ought afterwards to be worn for a considerable time. When the disease has been of long standing, adhesion takes place between the bladder and cellular substance of the scrotum. In this case, therefore, as long as no symptoms occur to render the operation necessary, a suspensory bandage, so fitted as effectually to support the prolapsed parts, is the only probable means of relief.

Sometimes the bladder, owing to a suppression of urine, at other times part of the intestines, have been found to protrude through the vagina. In the former case a fluctuation of water is perceptible to the touch.

The reduction is made by laying the patient on her back with her loins somewhat raised, and pressing with the forefinger from the vagina. Descents may in future be generally prevented, by evacuating the urine often, and by the use of a pessary introduced into the vagina. Nearly the same means are employed in reducing the intestine when it is found to protrude.

CHAP. XXIV. Of Hydrocele.

EVERY tumor formed by a collection of water might with propriety be named *hydrocele*, but the chirurgical acceptance of the term implies a watery swelling situated in the scrotum or spermatic cord. Hydrocele is either anasarcaous or encysted. In the former, the serum is chiefly diffused in the cellular substance: In the latter, the water is collected in a distinct bag. The scrotum with its contents are liable

Anasarctous to both varieties of the disease; so is the spermatic cord with its coverings.

Hydrocele of the Scrotum.

SECT. I. *Anasarctous Hydrocele of the Scrotum.*

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Symptoms of this disease.

As soon as water has collected in any considerable quantity in the scrotum, a soft, inelastic, colourless tumor is observed over the whole of it; impressions are easily received and retained for some time; the skin at first preserves its natural appearance, and the rugæ of the scrotum are not much altered; but as the swelling advances, they gradually disappear, and are at last totally obliterated. The swelling, from being at first soft, and of a consistence similar to dough, by degrees turns more firm, and the skin at last acquires an unnatural white shining appearance. The tumor at length becomes large; and though originally confined to the scrotum, it at last spreads up the groin. The penis likewise becomes affected, and often so swelled and distorted as to excite much inconvenience and distress; and although the scrotum is composed of parts which readily admit of dilatation, the tumor sometimes becomes so enormous that it bursts from one end to the other.

295
Treatment.

In the surgical treatment of this disease punctures made with the point of a lancet are most advisable, as large scarifications, in anasarctous habits, are sometimes apt to produce inflammation and mortification; while simple punctures readily heal, and can be renewed with very little pain as frequently as may be necessary: and besides, punctures are equally useful with the incisions; for as the cells of the scrotum communicate freely, if the punctures be made fairly through the skin, the water drains off very readily, though not so soon as by scarification. Previous to the operation, besmearing the part with some tough ointment of an innocent nature, and afterwards keeping it as dry as possible by a frequent renewal of dry soft linen cloths, in order to imbibes the moisture, is here a necessary piece of attention. The want of this seems to be the cause of much of the mischief which frequently ensues from operations of this kind. When scarifications or punctures go wrong by beginning to inflame and turn painful, &c. a cold solution of saccharum saturni, applied upon soft linen, proves most effectual in putting a stop to the farther progress of the inflammation, and affords most immediate relief to the patient in the present distress. Lime water, employed in the same manner, proves also a very useful application. When, however, the disorder proceeds to gain ground by a real mortification coming on, we should immediately have recourse to bark and other medicines usually employed in such affections.

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Sometimes owing to a local cause.

Although the anasarctous hydrocele, for the most part, depends upon a general dropical tendency, some instances occur of a local cause producing a mere local dropy of the scrotum. Thus, it has been known to happen from swellings in the groin and in the abdomen obstructing the passage of the lymphatics. When this is the case, if tumors producing such obstructions can be extirpated, no other means will afford such effectual relief; but when they are so deeply seated as to render any attempt for removing them improper, the practice we have already pointed out of making punctures in the most depending part of the tumor must be employed with a view to palliate such symptoms as occur. It sometimes happens in suppression of urine, whether arising from strictures in the urethra or from stones impacted in it, that the urethra bursts, and the urine in this manner getting access to the cellular texture of the scrotum, an anasarctous swelling rises immediately over the whole of it; nor does it commonly diminish till the cause by which it is produced is removed.

In order to prevent the formation of sinuses, which in

such circumstances will otherwise be apt to occur, an incision should be made into the tumor, and carried to such a depth as is sufficient for reaching the wound in the urethra. In this manner a free vent will not only be given to the urine already diffused, but the farther collection of it may probably be prevented. If a stone impacted in the urethra be found to be the cause of effusion, it should be cut out; and if the obstruction be produced by strictures in the urethra, they must be removed by a proper use of bougies. The cause being thus removed, if the habit of body of the patient is good, and untainted with any venereal or other general affection, by dressing the fore properly with soft easy applications, the opening into the urethra will probably heal, and a complete cure will in this manner be obtained. But when these ailments are complicated with any general affection, particularly with old venereal complaints, it frequently happens that neither mercury nor any other medicine has much influence in removing them.

SECT. II. *Hydrocele of the Tunica Vaginalis Testis.*

In the healthy state of the body, a small quantity of aqueous fluid is exhaled for lubricating the surface of the testicle, the superfluous part of which is absorbed by vessels appointed for that purpose. When the secretion of this fluid is either morbidly increased, or its absorption diminished, a preternatural collection of water is formed in the cavity of the vaginal coat, and hydrocele of the vaginal coat produced.

The symptoms are, a fulness at first observed about the inferior parts of the testicle, and most remarkable when the patient is erect, becoming gradually more tense as the disease advances; the tumor by degrees changing from the globular to the pyramidal form; no degree of pressure making the swelling disappear at any period of the disease. In the early part of the disease therefore, if it be not combined with hernia, or with a hydrocele of the cord, the spermatic process may be distinctly felt, because the swelling does not extend beyond the scrotum. In its more advanced state, it cannot be distinguished: the weight of the tumor now drags the skin of the neighbouring parts so much as to cause the penis almost to disappear; and in this state of the disease the testicle cannot be felt without much difficulty. On a minute examination, a hardness is always to be felt along that part of the scrotum where the testicle is situated; and at this point pressure excites some uneasiness. Fluctuation of a fluid may in general be distinguished through the whole course of the disease. In late stages, however, the appearance of a fluid is not very evident.

The transparency of the tumor has been generally supposed to be the principal criterion of this species of the disorder; but this must depend upon the nature of the contents, or thickness of the sac; so that, though the transparency of the tumor is a certain sign of the existence of water, its opacity cannot upon any account be considered as an indication of its absence. Through the whole course of the disease the tumor is not attended with pain, but some uneasiness is commonly felt in the back by the weight of the swelling of the spermatic cord. This is more particularly the case when a suspensory bandage is not used.

In the radical cure of hydrocele, in whatever way it is attempted, some degree of fever and inflammation will take place. Under the circumstances mentioned in the prognosis, the operation, if properly performed, is generally attended with the most complete success. But if the patient be very old, infirm, and diseased, an operation may be attended with such a degree of inflammation, and consequent sup-
puration,

Hydrocele of the Tunica Vaginalis Testis.

297
Symptoms of this disease.

298
Cure.

Hydrocele of the Tunica Vaginalis Testis. puration, as to be in danger of destroying a constitution already greatly impaired, and therefore ought not to be performed.

Various methods have been proposed for the cure of hydrocele, all of which may be reduced to two general heads: Such as have in view only a temporary relief, and which is therefore termed the palliative cure; and such as are meant to effect a radical cure. When the tumor has become so large as to be inconvenient from its size, an evacuation of the water by surgical means becomes necessary. In this case, if the patient either refuses to submit to the operation for a radical cure, or if his state of health render that operation improper, the palliative treatment, or a mere evacuation of the water by puncture, is the only means which can be employed.

299
Method of operating for the palliative cure

A lancet-pointed trocar was many years ago recommended for drawing off the water in this manner by the present Dr. Monro; and since that time it has in an improved state (fig. 77.), been recommended by Mr. Andree; another (fig. 78.) has been proposed by Mr. Bell. With any of these an opening may be made into the tunica vaginalis with safety.

The operator with one hand should grasp the tumor behind, to press the contained fluid to the anterior and under part of it. If a round trocar is to be used, a puncture with a lancet should be made where the trocar is to enter; but where a flat trocar is to be employed, the assistance of the lancet is unnecessary.

As soon as the instrument has pierced the vaginal coat, the stylette should be withdrawn, and the canula left in the cyst. The water will now run off; and if the tumor be not uncommonly large, it may be all drawn off at once; but as the sudden discharge of it, by taking off the support, might be in danger of rupturing some of the vessels, it should be discharged by slow degrees. When the whole is evacuated, a piece of adhesive plaster should be immediately applied to the orifice; and a compress of soft linen being laid over the scrotum, the whole should be firmly supported with a suspensory bag (fig. 79.) or a T bandage. The patient in this state being laid in bed, all kind of uneasiness is in a few minutes commonly gone, and he is able to follow his ordinary business without interruption.

300
For the radical cure.

The intention of every means now in use for the radical cure of this species of the disease, is to induce such a degree of inflammation on the parts in which it is seated as may obliterate entirely the cavity of the tunica vaginalis, by making it adhere to the surface of the testicle. The means at present generally employed for effecting a cure are, excision of the tunica vaginalis; the application of caustic; the use of a seton; a simple incision of the sac; and the injecting of acrid liquors into the tunica vaginalis, after drawing off the fluid which it contained. The method of cure, by the removal of the vaginal coat, is, first to lay open the vaginal coat, and then to cut it away by different snips of a pair of scissors. The sac being removed, the parts are to be dressed and treated in the same manner as in the operation where simple incision is used.

301
By excision of the tunica vaginalis.

302
By caustic.

The cure by caustic is attempted in the following manner: The scrotum being shaved, a piece of common paste caustic, properly secured with adhesive plaster, is applied, of about a finger's breadth, the whole length of the tumor; and if, on removing the caustic, it has not penetrated into the vaginal coat, an opening is made in it with a scalpel, so as to evacuate the contents, lay bare the testicle, and admit of proper dressings. But Mr. Elfe, one of the latest writers in favour of the method of cure by caustic, says, that there is no necessity for such an extensive application of caustic as many have recommended; that an eschar of the size of a shilling is sufficient; that this may be always fully obtained

by the application of caustic paste of the size of a sixpence, which is to be laid on the anterior and under part of the scrotum, and to be properly secured by plaster, in order to prevent it from spreading. The caustic commonly produces all its effects in five or six hours, and may then be removed. At this time digestives, or an emollient poultice, must be applied over the scrotum, and the whole suspended with a bandage. Inflammation, Mr. Elfe observes, is soon induced over the whole tunica vaginalis; and the febrile symptoms which succeed, he advises to be kept moderate by blood-letting, injections, emollient poultices, and a low regimen. In a few days the eschar of the scrotum separates, and comes away; and in a gradual manner, in the course of four, five, or six weeks, the whole tunica vaginalis comes off, when the wound for the most part soon heals, and a complete cure is obtained.

Where it is intended to treat hydrocele by means of a seton, it may be done in the following manner: An opening is made with a scalpel, or the sharp-pointed bistoury, in the superior part of the tumor, large enough to admit with ease a thick cord of common white sewing silk. A director, with an eye at one end, in which the cord is inserted, is introduced at this opening; and its farther extremity being carried down to the most depending part of the tumor, an opening is there made, of about half an inch in length, by cutting upon the director with the bistoury; the director being now drawn till a sufficient quantity of silk is left hanging out below, the operation is in this manner finished.

Another very simple method of introducing a seton is by means of a silver canula and perforator.

In the operation for a radical cure by incision, the patient being laid upon a table of convenient height, and properly secured by assistants, with the scrotum lying nearly on the edge of the table, the operator with one hand should grasp the tumor behind, so as to keep it firm and make it somewhat tense anteriorly: With a common round edged scalpel in the other hand, he should now divide the external integuments by one continued incision from the upper to the under end of the tumor. An opening is next to be made in the vaginal coat with a large lancet, or a sharp pointed bistoury (fig. 80.), at the upper end of the first incision. This opening should be of such a size as freely to receive the finger of the operator, which is to conduct a blunt pointed bistoury, so as to divide the sac down to its bottom, which is considered as being of advantage, by preventing partial adhesions and the risk of a return of the disease.

The incision being completed, the testicle is now brought fully into view; and if the tunica vaginalis be found, the dressing may be finished immediately. But if the sac be diseased, it is to be removed, which may be readily accomplished by a scalpel or bistoury.

When the hydrocele, as sometimes happens, affects both sides at the same time, if, when the operation is done on one side, an opening be made into the vaginal coat of the opposite side, at the upper part, through the septum scroti, and the incision carried down to the bottom of the tumor, the cyst can be equally well laid open, the water as completely evacuated, and a return of the disease as much prevented, as when the operation is done in the usual manner, and at different times.

In whichever way the incision is made, if the testicle be found, the wound ought to be quickly dressed; for it is found, that on this much of the success of the operation depends. For if the vaginal coat be merely applied to the testicle, or united by sutures, as some have advised, partial adhesions are apt to take place, before a degree of inflammation is produced over the whole sufficient for making a complete

Hydrocele of the Tunica Vaginalis Testis.

303
By a seton.

304
By incision.

Hydrocele
of the Tu-
nica Vagi-
nalis Tes-
tis.

complete cure. In this manner cavities are left, which either fill with pus during the cure, and require to be laid open, or they afterwards give rise to collections of water, and thereby occasion a return of the disease. The practice of stuffing the cavity of the scrotum with dressings is also a frequent cause of mischief, by exciting too great a degree of inflammation in the part. But when the dressings are properly managed, symptoms of violence almost never occur. The latest authors advise, that in dressing the parts after the operation, two pieces of lint or soft old linen are to be dipped in oil, or in a liniment of wax and oil, and then, by the help of a probe, are to be inserted into the bottom of the sac on each side of the testicle, leaving a sufficient quantity of the pledgets hanging out of the wound, so as to admit of being easily withdrawn at the first or second dressing. The edges of the wound are next to be dressed with pledgets of cerate, and the ends of the oiled pledgets turned over on each side. Several pieces of soft lint are then to be laid over the wound, and these should be more or less numerous in proportion to the heat of the season. A compress of linen is now to be laid over the whole, and the dressings supported by a T bandage or suspensory bag properly fitted. The patient is then to be carried to bed; an anodyne should be given, especially if there be much pain; and he ought to be advised to lie as much as possible upon his back for a few days after the operation.

In the third or fourth day after the operation, all the dressings, except those between the testicle and tunica vaginalis, are to be removed; and if this cannot be done readily, as the parts are otherwise apt to become uneasy, a sponge dipped in warm water should be applied. On some occasions, at the first dressing, and always at the second or third, the pledgets inserted between the tunica vaginalis come away; and whenever this happens, they should be renewed. It is also proper to renew them daily for the first fourteen or fifteen days after the operation; not however of the same depth as the first, for during the latter part of the cure they need only to be inserted as far as to prevent the divided edges of the tunica vaginalis from adhering to the testicle, before the adhesive process has taken place in the parts more deeply seated. Particular attention however is necessary to this part of the treatment; for when the disease returns, it has been found to be chiefly owing to the edges of the vaginal coat being allowed to adhere to the testicle, before adhesion had taken place between the deeper parts.

A complete adhesion of the two coats of the testicle, the tunica vaginalis, and tunica albuginea, takes place most frequently about the third week after the operation. Previous to this time, inflammation continuing gradually to increase, the tumor becomes larger till it acquire somewhat of the size of a swelled testicle from gonorrhœa; but after this period it gradually subsides, and the sore produced by the incision, and now reduced to a line, heals in some time between the fourth and eighth week, according to the habit of body, age of the patient, and other circumstances.

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Comparative advantages of each of these methods.

Having thus given an account of the methods usually employed in the cure of hydrocele, we shall now make a few observations on the comparative advantages of the three last. From the testimony of many authors of credit, it is evident, that any of these methods, in most instances, prove effectual; but every practitioner being apt to be prejudiced in favour of a particular method, he generally continues to follow that mode and no other; and finding it commonly succeed, he by degrees persuades himself, that other methods of cure, with which he has not had such opportunities of becoming acquainted, are liable to objections, which those who have practised them do not find to be the case. The result of

Mr B. Bell's observations upon this subject is, that although all the three modes of operating, by caustic, the seton, and simple incision, are perhaps equally capable of producing a radical cure; yet, that of the three, the latter, viz. the mode by the simple incision, is liable to fewest objections, and effects a cure, both with least trouble to the operator and least risk to the patient: and of the other two, the treatment by caustic appears to be the best. He has seen all the three produce troublesome symptoms, such as, pain and tension of the abdomen, inflammation, and fever; but hesitates not to say, that the seton is more frequently productive of these effects than any of the other methods.

Besides the methods already mentioned, another has been lately revived, viz. the injecting of irritating liquors into the vaginal coat of the testicle. This method is particularly described by a Monsieur Lambert of the last century, and may be of much older date for any thing which is known to the contrary. From some cause or other it seems to have been entirely laid aside till about the middle of the present century, when it was practised by Mr Monro (afterwards a physician-general in the West Indies), under the sanction of the late Dr Monro, and favourably received and followed by some of the first surgeons of this place. But in general, though the cure appeared complete, the disease returned.

The preference is usually given to wine, and commonly that is somewhat diluted; but where no pain is excited by the injection, the liquor should be discharged, and a stronger one used. For where no pain takes place, a cure is not to be expected.

The following is the most approved method of performing the operation: The operator should be provided with a flat trocar and canula, and with a bag of refina elastica, fitted with a stop-cock and pipe, which ought exactly to suit the canula. See fig. 81.

The patient being laid in an horizontal posture, either upon a bed or a table, the water should be drawn entirely off from the tumor by a flat trocar passed into the under and fore part of it. The operator securing the canula with the one hand, is with the other to pass the tube of the injection-bag fairly through it, and with gentle pressure to force in as much of the liquid as may reach the whole surface of the vaginal coat, as well as the whole surface of the testicle. The bag should now be removed, leaving the tube within the canula of the trocar, so that by turning the stop-cock the injection may be retained in the cavity of the tumor. The canula of the trocar ought still to be kept fixed, otherwise it might recede, by which the liquid would insinuate into the cellular substance of the scrotum. The liquor should likewise be brought into contact with every part of the cavity; and after remaining about four, or at the most five, minutes in the sac, it should be entirely discharged through the canula of the trocar, after withdrawing the tube of the elastic bag.

Sometimes intense pain is felt immediately after the liquor is thrown in. When this is the case, it should be discharged as soon as it has passed over the different parts of the tunica vaginalis. Some recommend a repetition of the same kind of injection immediately after the first has been discharged, and to be retained for the same period, though this is not commonly practised.

The whole of the injection should be completely discharged, after which the scrotum should be covered with a pledget of cerate, a compress being applied over it, and retained with a suspensory bag. The patient ought to be in bed for several days, and support the scrotum in the bandage by means of a small pillow.

Though it is difficult to ascertain the proportion of those who

Hydrocele
of the Tu-
nica Vagi-
nalis Tes-
tis.

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Radical
cure by
injection.

Hydrocele who are cured by the method of injections, and though it is to be regretted that hitherto the disease is found to return in a great proportion of those upon whom this operation has been performed; yet, on account of the facility with which it can be done, the comparatively small pain with which it is attended, the quickness of the cure, and chiefly because it does not, in case of a return of the disease, preclude the future operation of incision, it appears a method which, in all probability, will be more and more adopted in practice.

SECT. III. Of Hydrocele of the Spermatic Cord.

³⁰⁷ **Anasarca** of the spermatic cord sometimes accompanies ascites, and at other times it is found to be confined to the cellular substance in or about the spermatic cord. The causes of this disease may be, obstructions in the lymphatics leading from the part in consequence of scirrhus affections of the abdominal viscera, or the pressure of a truss applied for the cure of hernia.

³⁰⁸ **Symptoms.** When the affection is connected with anasarca in other parts, it is then so evident as to require no description. When it is local, it is attended with a colourless tumor in the course of the spermatic cord, soft and inelastic to the touch, and unaccompanied with fluctuation. In an erect position of the body it is of an oblong figure; but when the body is recumbent, it is flatter and somewhat round. Generally it is no longer than that part of the cord which lies in the groin, though sometimes it extends as far as the testicle, and even stretches the scrotum to an uncommon size; an instance of which is related by Mr Pott, who from a swelling of this kind discharged 11 English pints at once. By pressure a great part of the swelling can always be made to recede into the abdomen. It instantly, however, returns to its former situation on the pressure being withdrawn.

When the tumor is connected with general anasarca of the system, it can only be cured along with the rest of the disease; but when the swelling is local, the remedy is also to be locally applied. An incision is to be made of such a size as may be sufficient for discharging the whole of the water; in the performance of which, attention is necessary to guard against hurting the spermatic vessels. The contents of the tumor being discharged, the sore is to be treated like any other simple wound.

³⁰⁹ **Of encysted hydrocele** of the spermatic cord sometimes begins in the upper, but generally at the lower part of the spermatic cord. On its first appearance it is so small as to give little or no trouble; hence it is seldom particularly attended to till it has acquired a considerable size. By degrees it extends as far as the abdominal muscles, and sometimes reaches to the bottom of the scrotum; and to a person unacquainted with the appearance of the disorder may be mistaken for a hydrocele of the tunica vaginalis. But here the tumor is always above the testicle, which is distinctly felt below; and even in the advanced state of the disease the testicle is found in the back part of it perfectly unconnected with the swelling; whereas, in the advanced stages of hydrocele in the vaginal coat, although some hardness is discovered where the tunica vaginalis adheres to the testicle, yet when the swelling is great the testicle cannot be distinctly felt. In the encysted hydrocele of the cord, the figure and size of the penis is little altered; whereas, in cases of common hydrocele, the penis frequently disappears almost entirely. In other respects the two diseases are nearly similar. It sometimes happens that the water is contained in two distinct cells. In that case the tumor is somewhat puckered up, or diminished in its diameter. A similar appearance also occurs, when this variety of the disease is connected with hy-

drocele of the tunica vaginalis, which sometimes takes place.

The only other tumors with which this one may be confounded are, the anasarca of the spermatic cord, and a real hernia. But in neither of these is the fluctuation of a fluid perceptible, and to the touch they are both soft and inelastic; whereas, in this variety of hydrocele, the tumor has a springy feel, and a fluctuation is sensible to the touch; and in both the one and the other the swelling recedes somewhat upon pressure, which it never does here.

From hernia it is chiefly distinguished by the tumor beginning some way down the cord. In hernia the tumor turns less when the patient is in an horizontal posture, and is considerably affected by coughing and sneezing; but this kind of hydrocele is not altered in size by any such circumstances, nor has it the common symptoms which attend a hernia.

Infants are frequently subject to this disease, as well as to an anasarca swelling of the cord, and an oedematous tumor of the scrotum. But here the complaint is seldom permanent; for in most instances it readily yields to gentle friction, with any stimulating or astringent application, as a strong solution of sal ammoniac in vinegar, &c. But in adults, the cyst, in every variety of encysted hydrocele, becomes so firm as not to be affected by external applications; so that when the tumor becomes large, it is necessary to use means for producing either a palliative or radical cure, in the same manner as is done for a hydrocele in the vaginal coat.

SECT. IV. Of Hematocele Scroti.

We shall mention in this place the disease called *hematocele scroti*, which is occasioned by blood extravasated in the inner substance of the scrotum, in the tunica vaginalis, or in the spermatic cord; but the usual situation is in the tunica vaginalis testis.

Tumors of this kind may be produced by any thing which ruptures the blood vessels of the part, but they are commonly the consequence of external violence. In the tunica vaginalis this disorder may be produced by the point of a trocar or of a lancet in tapping for hydrocele. In such a case, we are commonly informed of the accident by blood being discharged along with the water; though sometimes it does not appear till the whole of the water is evacuated, and then a tumor of a considerable size suddenly takes place. Sometimes it happens where the quantity of water has been so uncommonly great that the sudden discharge of it, by taking away the support which the vessels have been accustomed to receive, has been the cause of their rupture; and it seems certain, that whenever a tumor is produced either in the scrotum or cord suddenly after the water of a hydrocele has been evacuated by tapping, that it is entirely owing to an extravasation of blood.

In the spermatic cord injuries of the same kind will be attended with a similar effect upon the vessels of the sac containing the water. The distinction between blood and water in the substance of the scrotum is readily made by the colour; for where the disease is produced by blood, it forms a real ecchymosis. The tumor feels heavier in the tunica vaginalis when filled with blood than where it is filled merely with water; the treatment is nearly the same with that in hydrocele. In the commencement of the anasarca or diffused hematocele, when produced from slight external violence, the application of stimulating or astringent fluids will sometimes disperse it; but if this prove ineffectual, the tumor is to be laid open, and treated exactly as was directed for hydrocele; only if a ruptured vessel be discovered, it must be secured by ligature. In like manner, all collections

Varicocele, Circocoele, Spermatocele, and Pneumatocele. of blood either in the vaginal coat or spermatic cord are to be laid open, and treated as in hydrocele. If bleeding vessels appear, they are to be secured. Sometimes, however, these cannot be detected; an oozing takes place which it is difficult to restrain, even by the use of bark, vitriolic acid, and other means generally employed in such cases. It has been uniformly found, that local remedies prove chiefly useful here, particularly the application of ardent spirits, æther, or tincture of myrrh, to the surface of the fore. Pledgets of soft lint, soaked in one or other of these, not only serve to check the discharge of blood, but in general tend to promote the formation of good matter.

CHAP. XXV. *Of Varicocele, Circocoele, Spermatocele, and Pneumatocele.*

³¹¹ **Varicocele.** VARICOCELE is a preternatural distension of the veins of the scrotum, which in this state form a tumor of hard, knotty inequalities, seldom painful, and generally attended with no inconvenience excepting what arises from its bulk.

³¹² **Circocoele.** Circocoele is similar in its nature to the former, but situated in the spermatic cord, extending from the abdominal ring to the superior part of the scrotum, and produced by a varicose state of the spermatic vein. Both of these disorders are occasionally produced by obstruction in the veins; but are most frequently owing to a relaxed state of these vessels; to which we may add, that on account of the smallness of the corresponding artery, they are not sufficiently affected by its influence. The tumor produced by these disorders is sometimes so large as to appear like a hernia or hydrocele; but we distinguish it from these by the touch, for varicose veins are like worms filled with elastic matter. We have another mark upon which we can still more depend: The tumor in the erect posture of the body is much increased, while in the horizontal situation it almost entirely disappears.

³¹³ **Of collections of blood within the tunica albuginea testis.** Another disorder is observed by late authors, where a collection of blood is sometimes found within the tunica albuginea testis, and is supposed to be a kind of hæmatocele, or more probably varicocele. Sometimes the collection is so considerable, that a fluctuation resembling that of an hydrocele of the vaginal coat of the testicle is observable. When this is mistaken for hydrocele, and an opening is made into it with a trocar, a discharge is produced of a dusky-coloured blood, somewhat resembling thin chocolate: But though the tumor may be diminished by the evacuation thus obtained, yet the alteration is inconsiderable; nor is the patient ever relieved, but on the contrary made worse by such an operation. Castration, after this, becomes necessary; but even this has been found ineffectual: so that the patient had better be advised to trust to nature, assisted by a proper suspensory bandage, than to suffer the attempt of a radical cure; for it has been observed, that in some instances they have remained stationary for many years, whereas they never fail to become much worse by any attempt to evacuate the fluid.

When tumors, or the pressure of a truss, has been the cause of such complaints, a proper attention to these ought to be the first attempt towards a cure. But when a relaxed state of the veins is suspected, we ought to recommend a suspensory bandage, an horizontal posture, the cold bath, and the application of a solution of alum and other astringents. By a proper exhibition of these, the disease may at least be prevented from increasing, so as to render any operation unnecessary.

³¹⁴ **Spermatocele.** By spermatocele is understood a morbid distension of the vas deferens and epididymis. The disease may arise from tumors, stricture, or inflammation about the vas deferens,

or its termination in the penis; but more probably from inflammation there. When an inflammatory disposition is discovered, general and topical blood-letting, gentle laxatives, a low cooling diet, and rest of body, will commonly be found the best remedies. When tumors are found to press upon the vas deferens, they ought either to be brought to a state of suppuration, or entirely extirpated, if that can be properly effected. If the disease proceed from a venereal cause, nothing can be so useful as a course of mercury properly directed.

By pneumatocele is understood a distension of the scrotum from a collection of air. ³¹⁵ **Pneumatocele.**

The principal cause of this disease, which rarely happens, is wounds in the lungs, by which air passes through the common cellular substance into the scrotum; but from whatever cause the tumor is produced, the disease is to be treated by making small punctures with the point of a lancet, as in the case of anasarctous swellings formed by water.

CHAP. XXVI. *Of Sarcocoele, or Scirrhus Testicle.*

SARCOCELE implies a fleshy, enlarged state of the testicle, much firmer and harder to the touch than is observed in hernia humeralis or inflamed testicle.

The symptoms vary exceedingly in different patients; but the following are the most general: The first symptom is commonly a small enlargement, without much pain, and no discoloration of the part. The tumor becomes gradually larger, and the hardness increases; but for a considerable time the surface remains smooth; and when the constitution is otherwise good, the disorder will sometimes remain in this situation for a considerable number of years; and in a few rare instances, by a moderate diet, keeping the belly open, suspending the tumor properly, and avoiding violent exercise, or any thing which may considerably increase the impetus of the blood, the disorder has not only been prevented from increasing, but has in a gradual manner disappeared entirely. More commonly, however, the tumor increases in size, and becomes ragged and unequal on its surface. Smart and severe shooting pains are frequently felt through its substance. Sometimes serum is extravasated in the vaginal coat, or matter is collected in different parts of the tumor. The scrotum, now much distended, bursts, and thin, fetid, bloody matter discharging, the disease terminates in an ulcerated cancer of the worst kind.

The spermatic cord is commonly unaffected till the tumor has acquired a considerable size, and generally not till collections of matter have been formed. After this, from being at first only slightly swelled, it gradually increases in hardness and bulk; after which it becomes very painful, knotty, or unequal through its whole extent. The discharge from the scrotum still continues; but although the matter increases in quantity, the size of the tumor is not thereby diminished, but, on the contrary, continually increases; the edges of the fore become hard, livid, and retorted, and fungous excrescences push out from every part of it; the health of the patient becomes entirely destroyed, and he is at last carried off in great misery.

Hernia humeralis produced by venereal infection has been considered, by some authors, as a frequent cause of the worst kind of scirrhus testicle; but the fact is very much otherwise; and such an idea has this bad tendency, that it prevents the perseverance in the use of such remedies as might have removed the disease without the necessity of extirpation.

Another cause mentioned by authors as producing scirrhus

Sarcocoele, or Scirrhus of the Testicle. Sarcocoele, scirrhus of the testicle, is the hydrocele of the vaginal coat; but though sarcocoele is frequently combined with this disease, there is every reason to think that the primary disorder was in the testicle itself, and that the water is only a consequence of the other complaint. When the hydrocele happens to be the original disease, the testicle is also found frequently altered in its appearance. It is here paler than in its natural state. It is sometimes diminished, but more frequently enlarged. The enlargement however is soft, harmless, and free from pain; and in such a situation should never be extirpated. To this point particular attention ought to be paid, otherwise we run the risk of committing a mistake, into which practitioners have been too frequently led—the extirpation of a testicle which ought to have been saved. To keep free of this error, we ought to attend to the following circumstances.

³¹⁶ In what cases the testicle may be extirpated. When the disease begins in the testicle itself, especially in the body or glandular part, or when it becomes hard and enlarged previous to any collection of water in the vaginal coat, it is to be considered as of a different nature from that in which an enlargement of the part succeeds to a collection of water; or if, upon evacuating the water, the testicle be found hardened, enlarged, and attended with pain and other marks of scirrhus, especially if the surface be unequal or ulcerated, extirpation ought certainly to be performed. The symptoms above mentioned sometimes, though rarely, begin in the epididymis. In such cases, however, extirpation will seldom be advisable, as there is here always a suspicion of a venereal affection; and then we ought by all means to try the remedies commonly used in such diseases. In the prognosis, we attend to the age and habit of the body, as well as to the state of the disease and length of time it has continued.

When the patient is young and the constitution unbroken, we may always hope for a cure, although the symptoms should be very considerable; whereas, in old infirm people, and in habits attended with an emaciated look, with indigestion, and other symptoms of obstructed viscera, whatever state the disease may be in, there will be but a small chance of success.

If the disease has subsisted for a long time without considerably increasing in size, we may reasonably think it is of a milder nature than where it has made a rapid progress. As long as the testicle is only hard and free from the formation of matter, we may expect a favourable event; but where collections of matter have already formed, either in the substance or upon the surface of the testicle, there is no other chance of saving the patient than by means of extirpation. Previous to this, however, we are to attend to the state of the spermatic cord; for were any of it left in a diseased state, little advantage could be derived from extirpation; nor ought the operation ever to be performed but where we can reach the whole of the diseased parts. We are not to be prevented from performing it though the cord should be considerably enlarged, providing it do not evidently partake of the disease of the testicle; for the cord is generally somewhat enlarged in the diseased state of the testicle; but this enlargement is for the most part merely either a varicose state of the veins, or a watery disposition of the cellular substance.

³¹⁷ Method of performing the operation. But supposing no obstacle to the operation, the method of doing it may be this. The parts being previously shaved, the patient is to be laid upon a square table of about three feet four inches high, letting his legs hang down; which, as well as the rest of his body, must be held firm by assistants; or, he may be laid across a bed in the same manner. Then with a knife the incision is to

be begun above the rings of the abdominal muscles, that there may be room afterwards to secure the vessels; then carrying it through the membrana adiposa, it must be continued downward to the bottom of the scrotum. A firm, waxed, flat ligature, composed of small threads, is next, by means of a curved needle, to be passed round the spermatic cord, at least an inch above the diseased part, or as near the abdominal ring as possible; after which the vessels are to be secured by a running knot, and divided about a quarter or half an inch below the ligature. The cord and testicle are then to be removed from the surrounding parts by dissecting from above downwards, and no instrument is better for this purpose than the common scalpel. After the diseased parts are removed, the knot upon the cord must be slackened to discover the spermatic arteries and veins; both of which, by means of the tenaculum or a common forceps, are to be taken up. The ligature upon the spermatic cord is now to be left loose, so as to act as a tourniquet if a hemorrhagy should ensue; nor is there more occasion for leaving the ligature tied than for leaving a tourniquet firmly applied to one of the extremities after amputation; besides, where patients have suffered such pain as is sometimes mentioned by authors, it has been found to be owing to the tightness of the ligature rather than to any other cause. In dividing the ligatures of the blood-vessels at the extremities of the cord, they must be left of such a length without the wound as to be readily removed, however much the cord may retract in the time of the cure.

In separating the testicle, a considerable hemorrhagy sometimes ensues from the division of the scrotal arteries. In such a case, they ought always to be fixed with ligatures before proceeding in the operation. The parts being removed, and the blood-vessels secured, the wound is to be cured, if possible, by the first intention; and for this purpose the sides of the scrotum are to be brought together in the most accurate manner, beginning at the under end, and securing the parts by adhesive plaster as we proceed upwards, and in such a way that the sides of the fore may be kept properly together. About two inches of the ligatures of the cord are to be left out, and this part of the wound treated in the same manner as the rest; the whole to be secured by a compress of linen and a T bandage.

³¹⁸ Treatment after the operation. The patient should now be laid to rest, and an opiate administered; and if, upon the second or third day, any inflammatory symptoms ensue, they are to be removed by methods commonly employed upon these occasions; as, topical blood letting, gentle laxatives, and keeping the part constantly moist with a solution of sugar of lead. The dressings ought not to be allowed to shift, else the cure will be greatly retarded. They are to be examined about four or five days after the operation; and if nothing material has happened, they may be allowed to remain two or three days longer, by which time generally the ligature can be readily removed; and the wound will be healed by the first intention, excepting some small opening in the skin, more especially where the ligatures were placed. These are to be drawn together by adhesive straps, and dressed in the same manner as formerly. In this way, if the patient be otherwise healthy, a cure may be expected in little more than a fortnight.

The method of dressing most frequently practised is to apply a quantity of soft lint to the fore, and then a compress of linen over it, and to secure the whole with a T bandage or a suspensory bag. The patient is then laid to rest, and an opiate given. The fore is not to be touched till a free suppuration takes place, which will commonly be about

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about the fifth or sixth day, and then the dressings are to be removed, and renewed from time to time; once every two days, or oftener, as the quantity of matter may render it necessary. Sometimes after the operation the patient complains of pain in the fore, and of tension and uneasiness in the belly. In such a case, warm fomentations should be applied to the abdomen, and the fore covered with an emollient poultice, and this repeated as often as may be necessary.

CHAP. XXVII. Of the Stone.

SECT. I. Of Stone in the Bladder.

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Causes of
the forma-
tion of cal-
culi.

A VARIETY of causes have been assigned as tending to the formation of calculi in the bladder of urine; as, a decomposition of a superabundant quantity of earthy matter from the blood, on account of a sedentary life; certain articles of diet or drink, containing a greater quantity of earthy matter than others; a continued use of solid food without a sufficient quantity of drink; the peculiar action of absorbent vessels; the particular structure of the kidney; the nature of the different excretory vessels; the time the urine may remain in the kidney; the habit of retaining the water in the bladder; particles of blood getting into the kidney or bladder, and attracting the stony matter so as to form a nucleus. A certain change of the vessels of the kidney forming the urine has by some been considered as a more probable cause than any of the former. The formation of calculus sometimes begins in the kidneys, at other times in the bladder.

After a calculus has begun to be formed, it sometimes acquires a great size in a few months from the first obvious symptoms; but sometimes it remains in the bladder for many years without arriving at any considerable size.

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Symptoms
of calculus.

The symptoms commonly come on gradually, and bear some kind of proportion to the size and inequalities of the stone. One of the first commonly taken notice of is an uneasy sensation at the point of the urethra, which for some time is perceptible only upon making water, or upon using violent or jolting exercise. This sensation gradually increases; and there is along with it a frequent desire to make water, which is commonly voided in small quantities, and sometimes only in drops. When running in a full stream, it often suddenly stops, though the patient is conscious that a considerable quantity still remains, and feels a strong inclination to void it. If the stone be large, the patient has a constant dull pain about the neck of the bladder, and frequent desire of going to stool. The urine is generally of a limpid colour; but it is frequently thick, depositing a mucous sediment, and when the disease is violent it is often tinged with blood. All these complaints are greatly increased by exercise, especially by riding on horseback; and from a long continuance of pain, the patient's health by degrees becomes much impaired, and unless effectual means are employed for removing the cause of the disorder, death alone puts an end to his misery.

We are rendered certain of the existence of calculus when small pieces of stone are frequently passed along with the urine. When this does not occur, we cannot be certain that the symptoms do not arise from an ulcer or tumor in the body or neck of the bladder, or from the pressure of tumors in the neighbouring parts. In doubtful cases, however, we have one mark by which we can judge with certainty, and that is by means of sounding.

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Method of
sounding.

This is performed by introducing an instrument called a *sound* (fig. 82.), formed of steel finely polished, and having the natural curvature of the urethra. The patient is to be

laid upon a table or across a bed, with his shoulders raised upon a pillow, to bring the stone to the neck of the bladder, and his thighs a little elevated and separated from each other. A sound adapted to the size of the urethra is to be chosen; and previous to the introduction it is to be laid in warm water till it be of the heat of the body, and then wiped and rubbed over with bland oil, butter, or axunge. The surgeon lays hold of the penis with his left hand, while with his right he introduces the sound with its concave side towards the abdomen. He is now with his left hand to draw the penis gently forward upon the instrument, which is to be gradually pushed into the bladder. If any difficulty occur about the neck of the bladder, this may be obviated by introducing the finger into the anus, and raising the point of the instrument; or the same purpose is more readily answered by depressing the handle of the sound. If still it does not pass with ease, much force ought by no means to be used, lest the instrument perforate the membranous part of the urethra.

As soon as the instrument enters the bladder, if it happen at once to touch the stone, a tremulous motion will be communicated to the fingers of the operator, and the business of sounding is then accomplished, the nature of the disease being now ascertained. Great care, however, is here always necessary, as a few particles of sand, or a hardened state of the bladder, have sometimes communicated the same sensation. If the stone be not soon discovered, the instrument is to be moved in all directions; and should the operator be still unsuccessful, one of the fingers of the left hand is to be introduced into the rectum, so as to raise that part of the bladder in which a stone may probably be concealed. If even this attempt prove ineffectual, the body of the patient is to be put into different positions, and perhaps one of the best is depressing the shoulders and raising the pelvis. By this mean a stone may generally be felt, providing it is not contained in a cyst, which very rarely happens. If after all these different attempts the surgeon should fail in discovering the stone, the instrument is to be withdrawn; and if symptoms of stone be strongly marked, and it appear that neither scirrhus nor inflammation, which might give rise to these symptoms, do exist, a second or even a third trial is to be made on the following days.

Various lithontriptics have been recommended for dissolving the stone in the bladder; such as lime-water, caustic alkali, soap, &c. but none of them can be conveyed in such a state into the bladder as to be much depended upon, as they undergo the greatest change in the course of the circulation. To obviate these changes, it has been recommended to inject certain fluids of this class through the urethra into the bladder; but this has not been attended with any material advantages, and has generally been found to do injury to the bladder. The only effectual method of removing stones from the bladder is by means of a surgical operation; the success of which depends much upon the dexterity of the surgeon, as well as on the constitution of the patient.

When the constitution has been so much impaired that the patient complains greatly of sickness and oppression at stomach, with nausea and an inclination to vomit, especially upon taking food; when he has likewise a constant thirst, and the pulse is as high as a hundred strokes in the minute—an operation is improper till these symptoms are removed. The operation is improper also when the patient labours under a severe fit of the stone; for then inflammation of the bladder is apt to ensue to such a degree as to produce supuration. By frequent attacks and continuance of these fits, the coats of the bladder are apt to be thickened and greatly contracted. This last circumstance may be known by the introduction of the sound; for then it will stop after

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ter getting past the sphincter of the bladder, and cannot be pushed farther without considerable force, and at the same time giving the patient the most exquisite pain. Nor ought the operation to be performed when the bladder is ulcerated, especially where the patient is old and much debilitated, and where the discharge of matter is great.

Children more readily recover from the operation of lithotomy than adults; and old people from the age of 55 to that of 70, whose constitutions have not been broken, are in less danger than those in the full vigour of life, probably owing to inflammatory symptoms being more apt to proceed to a dangerous length in the extremes of age than at the middle period of life. When the constitution, however, is not much impaired by the continuance of the disease, the operation may be undertaken with a probable degree of success almost at any period of the patient's life.

Several methods have been recommended for performing this operation; but there are only two which can be practised with any propriety. One is, where the operation is to be performed immediately above the pubes, in that part of the bladder which is not covered with peritonæum: the other, where it is done in the perinæum, by laying open the neck and lateral part of the bladder, so as to allow of the extraction of the stone.

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High operation.

Franco, a French surgeon, finding a stone in a child of two years of age too large to be extracted through an opening in perinæo (the place where the operation was then performed), was induced to make an incision into the bladder above the pubes; but though the stone was extracted and the child recovered, Franco, who published the case in 1561, never attempted the operation again, and even dissuades others from doing it. It does not appear indeed to have been much practised anywhere till some time after the commencement of the present century, about the year 1720, when it was adopted and frequently performed in Britain and other parts of Europe for the space of about 12 or 15 years. The lateral operation came then to be more generally known, and since this period the high operation has been seldom practised.

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Method of performing it.

In performing the high operation, the bladder must be in a distended state, so as to make it rise above the ossa pubis, to allow an incision to be made into that part of it which is uncovered by the peritonæum, and thereby to prevent the abdomen from being opened or its contents exposed. Some days, or even weeks, previous to the operation, the patient ought to be desired to retain his urine as long as he can, so as to distend the bladder till it can hold at least a pound and a half, when the person is an adult and of an ordinary size; or the penis may be tied up to allow the urine to collect. As these methods may be attended with great distress, some prefer distending the bladder by injecting warm water by slow degrees till the bladder is sufficiently full, which may be easily known by relaxing the abdominal muscles and feeling above the pubes.

When the operation is to be performed, the patient is to be laid upon a table of convenient height, with the pelvis higher than the shoulders, that the parts may be fully on the stretch, and to prevent the bowels from pressing upon the bladder. The legs and arms are to be properly held by assistants. An incision is to be made through the skin, in the very middle of the under and fore part of the abdomen, from some way under the umbilicus to the symphysis pubes. The cellular substance, the tendon of the oblique muscles, the muscoli recti and pyramidales, are now to be separated; and it is better to make this separation from the pubes upwards, so as to be in no danger of cutting into the abdomen. The surface of the bladder will now appear uncovered by the peritonæum. Then the operator, with a

common scalpel, or an abscess lancet, or, what is better, with a concave sharp-pointed knife, makes a perforation into the most prominent part of the bladder, till the fore-finger of the left hand can be introduced. The ligature is now to be removed from the penis; then with a probe-pointed bistoury, making the finger serve as a conductor, the wound is to be made sufficiently large for the extraction of the calculus, taking particular care, however, not to carry the incision so high as to cut the peritonæum. This part of the operation being finished, the stone is to be extracted with the finger; or if that be impracticable, the forceps are to be employed. Should it unfortunately happen that the stone is broken in the extraction, the pieces are to be removed entirely by the fingers rather than by scoops, which were sometimes used. The edges of the wound in the integuments are now to be drawn together by means of the twisted suture, leaving about an inch and a half immediately above the pubes for the discharge of any urine which may be there evacuated. The patient is to be laid in bed, with the pelvis still kept higher than the shoulders. Gentle laxatives are to be occasionally given, and the antiphlogistic plan strictly adhered to.

The advantages of this method are, that larger stones can be extracted by this than by the lateral operation, and that fistulous sores are less apt to ensue. The disadvantages are, the danger of opening or wounding the peritonæum, and thereby exposing the abdominal bowels; the frequent occurrence of inflammation about the beginning of the urethra, so as to occasion the urine to be diffused in the cellular substance on the outside of the bladder, and thereby producing sinuses difficult to cure; the extreme difficulty of healing the wound, especially in bad constitutions; and, lastly, the small number of patients, after the age of thirty, who have been found to recover from this operation.

Frere Jacques, a French priest, was the inventor of the lateral operation. He first appeared at Paris in 1697, and afterwards operated in a great number of cases.

He introduced a sound through the urethra into the bladder with a straight bistoury, cut upon the staff, and carried his incision along the staff into the bladder. He then introduced the fore finger of the left hand into the bladder, searched for the stone, which, having withdrawn the sound, he extracted by means of forceps. The patient was now carried to bed, and the after treatment left to the attendants.

Professor Rau of Holland improved upon this method, by making a groove in the staff, which enabled him, with greater certainty, to continue his incision into the bladder: but instead of dividing the urethra and prostate gland, the latter of which he was afraid of wounding, he dissected by the side of the gland, till the convex part of the staff was felt in the bladder, where he made his incision, and extracted the stone; but this method was too difficult to perform, and attended with too many inconveniences and dangers ever to be generally received. It suggested, however, to the celebrated Cheselden the lateral method of cutting, as it is the lateral now with a few alterations very generally practised. We shall attempt to describe the different steps of this operation in its present improved state.

The manner of preparing the patient depends upon a variety of circumstances. If he be plethoric, a few ounces of blood should be taken away, and at proper intervals the bowels ought to be emptied by any gentle laxative which will not gripe. The diet should consist of light food for some time previous to the operation. If the pain be violent, opium is necessary. Sometimes it is relieved by keeping the patient in bed with the pelvis raised, so as to remove the stone from the neck of the bladder. He ought not to

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fit up, or take any exercise, in the time of preparation. The warm bath ought to be used two or three times, and the patient should remain in it half an hour at each time. A laxative ought to be given on the day preceding the operation, and an injection a few hours before it is performed. The patient ought to drink plentifully of some diluent liquor, and to retain the urine several hours previous to the operation. If this cannot be readily affected, a slight compression, by means of a ligature, may be made upon the penis, so as to have the bladder sufficiently distended, that there may be no danger of the posterior surface being hurt by the end of the gorget. The perinæum and parts about the anus should be well shaved.

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Manner of
performing
the opera-
tion.

A table somewhat more than three feet in height, and of sufficient strength, is now to be firmly placed, and properly covered with blankets, pillows, &c. Upon this the patient is to be laid and properly secured; and for this purpose there ought to be two pieces of broad firm tape, each about five feet in length, which are to be doubled, and a noose formed upon them. A noose is then to be put upon each wrist, and the patient desired to lay hold of the middle of his foot upon the outside. One end of the ligature is to go round the hand and foot, and the other round the ankle and hand, and cross again, so as to repeat the turns in the reverse way. A running knot is then to be tied, by which the hand and foot will be properly secured. The buttocks are then to be made to project an inch or two over the table, and to be raised considerably higher than the shoulders by a couple or more pillows, and one ought to be put under his head.

The operator is now to introduce a grooved staff (fig. 83.) of proportionable size, and open to the very end, through the urethra into the bladder; and having again fully satisfied himself of the existence of a stone, he inclines the staff, if the surgeon be right-handed, obliquely over the right groin, so that the convex part of the staff may be felt in the perinæum on the left side of the raphe. He then fixes it, and delivers it to his assistant, who is to hold it with his right hand, desiring him to press it gently, in order to make the sulcus of the staff project in the direction in which he received it. With his left hand the same assistant is to raise and support the scrotum.

The thighs of the patient being sufficiently separated by the assistants, and the surgeon being seated upon a chair of a proper height, and in a convenient light, he makes an incision with a common convex edged scalpel through the skin and cellular substance, immediately below the symphysis of the ossa pubis, which is a little below the scrotum, and where the crus penis and bulb of the urethra meet, and on the left side of the raphe, and continues it in a slanting direction downwards and outwards to the space between the anus and tuberosity of the ischium, ending somewhat lower than the basis of that process, by which a cut will be made of three or four inches in length. This incision ought not to be shorter than is here directed, otherwise there will not be room for the rest of the operation. As soon as the integuments are thus divided, he ought to introduce two of the fingers of the left hand. With one he keeps back the lip of the wound next the raphe, and with the other he presses down the rectum. He ought likewise particularly to guard against cutting the crura of the penis, which he can readily feel, and separate at their under part with one of the fingers. He next makes a second incision almost in the same direction with the first, but rather nearer to the raphe and anus, by which he preserves the trunk of the arteria pudica. By this incision he divides the transversalis penis, and as much of the levator ani and cellular substance within these as will make the prostate gland perceptible to the finger.

If any considerable vessel be cut, it is immediately to be secured, though this is seldom necessary. After this he will have a view of the membranous part of the urethra, which is distinguished from that covered by the bulb by being very thin. He is now to search for the groove of the staff with the fore finger of his left hand, the point of which he presses along from the bulb of the urethra to the prostate gland, which surrounds the neck of the bladder. He keeps it there; and turning the edge of the knife upwards, he cuts upon the groove of the staff, and freely divides the membranous part of the urethra, from the prostate gland to the bulb of the urethra, till the staff can be felt perfectly bare, and that there is room to admit the point of the finger; and as the finger assists in keeping the parts stretched, and effectually prevents the rectum from being hurt, the incision into the urethra may be made with perfect ease and safety.

The next part of the operation, viz. dividing the prostate gland and neck of the bladder, might, by a dexterous operator, be safely performed with a common scalpel, with the edge turned the opposite way. But to guard against accidents, a more convenient instrument, called the *cutting gorget* (fig. 84.), is now in general use. It was originally invented by Mr Hawkins of London, and since his time has undergone various alterations. Fig. 85. is a double gorget invented by Dr Monro. The inner plate, which is blunt, is made to slip forwards to protect the back part of the bladder. The membranous part of the urethra being now divided, and the fore-finger still retained in its place, the point of the gorget, previously fitted to the groove, is to be directed along the nail of the finger, which will serve to conduct it into the groove of the staff; and as this is one of the nicest parts of the operation, the most particular attention is here required that the point of the gorget be distinctly heard to rub in the bare groove, and that nothing is interposed.

In the introduction of the gorget into the bladder, if the assistant could be depended upon, the staff might be allowed to remain in his hand: the operator, however, generally chooses to manage it himself. He now rises from his seat, takes the staff from the assistant, raises it to near a right angle, and presses the concave part against the symphysis of the ossa pubes; satisfies himself again that the point or beak is in the groove, and then pushes on the gorget, following the direction of the groove till the beak slip from the point of the staff into the bladder. The gorget is not to be pushed farther than this, otherwise it may wound the opposite side of the bladder, &c.

The gorget having now entered the bladder, which is readily known by the discharge of urine from the wound, the staff is to be withdrawn, and the finger introduced along the gorget to search for the stone, which, when felt, will point out the direction to be given to the forceps; at any rate, the introduction of the finger serves to dilate the wound in the bladder; and this being done, a pair of forceps (fig. 86.) of a proper size, and with their blades as nearly together as their form will allow, are to be introduced, and the gorget withdrawn slowly, and in the same direction in which it entered, so as to prevent it from injuring the parts in its return. After the forceps are introduced, and passed till they meet with a gentle resistance, but no farther, the handles ought to be depressed till they are somewhat in an horizontal direction, as this will most correspond with the fundus of the bladder. One blade of the forceps is to be turned towards the symphysis of the pubes to defend the lost parts there, the other of consequence will guard the return. After they have distinctly touched the stone, by moving them a little in various directions, they are then to be opened, and the stone laid hold of, which may generally

Stone in
the Blad-
der.

Stone in the Bladder. rally be done with considerable ease. It frequently happens, however, that when the stone is small, it is not readily felt with the forceps; and instances may happen where the under and back part of the bladder may be so depressed as to conceal the stone. In such a situation, nothing will more readily bring it in the way of the forceps than to introduce the finger into the rectum, and elevate this part of the bladder. Straight forceps are generally used; crooked ones, in some very rare cases, however, may be necessary, and therefore the surgeon ought to be provided with them.

After the forceps has laid hold of the stone, if it be small and properly placed, it may readily be extracted; but if, on the contrary, the handles of the forceps are now observed to be greatly expanded, it is certain the stone is improperly fixed, or that it is remarkably large: in either case it should not be held fast, but allowed to move into the most favourable situation; or the finger is then to be introduced so as to place it properly for extraction. If this cannot be done with the finger, it ought to be allowed to slip out of the forceps, in order to get it more properly fixed; and as the most common form of the stone is flat and oval, or somewhat like a flattened egg, the forceps should have hold of the smallest diameter, while an end presents to the neck of the instrument. The stone should be grasped with no greater firmness than is merely sufficient to bring it fairly out. It should be extracted in a slow and gradual manner.

When a stone is broken in the bladder, all the larger pieces are to be extracted by the forceps, which are to be introduced by means of the finger serving as a director. The smaller parts are to be removed by means of a scoop (fig. 87.), or probably the finger may be more convenient; and as the least particle allowed to remain, or which is not washed off by the urine, may serve as the nucleus of another stone, a large quantity of water, properly warmed, is to be injected by a bag and pipe, or by a syringe; and for this purpose the body of the patient should approach at least to an upright posture; and to give the particles of stone an opportunity of collecting near the incision of the bladder, the wound may be stopped for a little after the injection is thrown in.

When a stone is extracted of a regular, firm, and rough surface, it seldom happens that any others remain in the bladder. On the contrary, when it is of an irregular shape, and smooth and polished, particularly in certain places, with impressions formed upon it, there is the greatest probability of others remaining. There are exceptions, however, to these rules; and therefore the operator, instead of trusting to them, should introduce his finger, which will answer the purpose without any other searcher.

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Treatment after the operation. If, after the operation, any considerable artery bleeds much, it is to be taken up with a ligature; but if this be impracticable, the hemorrhagy ought to be stopped by means of pressure, and for this purpose a firm roller introduced at the wound answers sufficiently: and to prevent any stoppage to the discharge of urine, a silver canula, covered with caddis, and dusted over with styptic powder, may be introduced into the wound with advantage.

Sometimes it happens that a considerable quantity of blood, instead of passing off by the wound, is collected in the cavity of the bladder, and may produce very dangerous symptoms. To prevent this as much as possible, immediately upon the operation being finished, the patient's pelvis should be made considerably lower than the rest of his body; by which means the wound will be kept in a depending posture, and the blood will escape more readily by the wound. But if it be found that blood is still lodged in the cavity of the bladder, it must be immediately extracted.

As soon as the bleeding is stopped, the patient is to be

untied, a piece of dry soft charpee put between the lips of the wound, and often renewed, and the thighs brought together. He is then to be laid in a bed, in such a way that the pelvis may be considerably lower than the rest of the body, to give a favourable direction to any blood which may afterwards flow from the wound. A considerable dose of laudanum is now to be given. From 30 to 50 drops for an adult will commonly be necessary. From this period, unless the stone has been large and difficult to extract, the patient commonly falls asleep, or at least lies quiet for a few hours; but afterwards generally begins to complain of pain in the under part of the abdomen. Anodynes are now to be given both by the mouth and anus, and warm fomentations, by means of flannels or bladders filled with warm water, are to be applied to the region of the bladder, as the affection seems to be of the spasmodic kind.

If by a continuance of these remedies the pain abates, no anxiety needs be entertained concerning it; but if it increase, and especially if the abdomen become hard and swelled, and the pulse full and quick, and these symptoms become gradually worse, great danger is to be apprehended, as they most commonly take place in consequence of inflammation. In this situation, as much blood ought to be taken as the patient can bear. A large injection of warm water and oil, or linseed tea, should be given every six or seven hours, and the fomentations continued at the abdomen. If the symptoms continue to grow worse, the patient should be immediately put into the semicupium or half bath.

By a proper continuance of these means, with a low diet and plenty of diluent drink, the above symptoms may frequently be removed. The reverse, however, is sometimes the case. The wound becomes sloughy and ill-conditioned; all the symptoms, in spite of every effort, continue to increase, and soon terminate in death.

But where matters end favourably, the wound by degrees puts on a better appearance; the urine passes almost from the beginning by the urethra (most frequently, however, it is discharged by the wound for the first two or three weeks); the pain in the abdomen gradually abates, the feverish symptoms are soon removed, a complete cicatrix is formed, and the wound is sometimes cured in a month; though upon other occasions three will be necessary. But it must depend greatly on the nature of the constitution.

Excoriation of the buttocks may be prevented by placing a sheet under them several times doubled, the breadth to be 18 or 20 inches, and to be all rolled up, except the part which is to be laid under the patient, the rest of the roll to be by his side, which is to be unrolled as the nurse draws the wet part from under him. If, after the use of this, excoriations should still happen, the part may be washed with cold water; or the parts round the wound, after being well dried, may be rubbed with any tough simple ointment.

In patients of a debilitated constitution incontinence of urine frequently occurs after this operation. In general, this is removed as the patient acquires strength. Nourishing diet, cold bath, the bark, and other tonics, are of much service here; but where these are afterwards found ineffectual, instruments for compressing the penis, or others for receiving the urine, have been found useful, and are now made in such a convenient way as to allow them to be constantly used so long as they may be found necessary.

An operation for stone in the bladder is much seldomer required in women than in men, on account of the shortness of the urethra in the former allowing a readier passage for the small calculi which get into, or are formed in, the bladder. It is likewise in women more simple, and of course more readily performed. It might be done in the same manner

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Lithotomy in females.

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neys.

manner as in the male, but there would be the greatest probability of wounding the vagina. In a few cases the operation has been performed from the vagina itself; but it is by no means advisable, as stones would not only be extracted with greater difficulty, but, on account of the thinness of the parts, the urine would most probably form a fistulous opening, and a communication be maintained between the bladder and vagina; or cicatrices here might be attended with great inconvenience in child-labour.

In the method commonly practised, the patient being placed and secured in the same manner as in the operation upon the male, the operator introduces a short grooved staff, slightly curved (fig. 88.), into the bladder; then by means of the common gorget already mentioned, with its point passed along the groove of the staff, he lays open the whole of the urethra and the neck of the bladder. The staff is now to be removed, the finger introduced upon the gorget, and to feel for the stone, which is to be removed as already directed for the operation on the male subject. Where incontinence of urine occurs after the wound is healed, a pessary is to be used within the vagina, or a sponge applied, or a tin machine to receive the urine.

SECT. II. *Of Stones in the Kidneys.*

THE symptoms of stone in the kidneys are, pain in the region of the kidneys, sickness, and vomiting, the urine sometimes mixed with blood, at other times with mucus or even purulent matter; but the same symptoms are often induced by other causes, especially from inflammation and suppuration of the kidney. Nephritic complaints have frequently subsisted for a long time, where stones have been blamed as being the cause of them; and yet upon dissection purulent matter alone has been detected. From this circumstance, as well as from the great depth of the parts and the large size of the blood vessels of the kidney, the operation of nephrotomy could not be performed, but with the greatest uncertainty and most imminent danger, and is therefore never attempted. A few cases indeed have appeared where inflammation induced by a stone in the kidney terminated in abscess, and the stones were taken out; but it was not till they had worked their way out of the kidneys into the cellular substance, so that it only remained to open the abscess and extract them; but otherwise the operation is never to be thought of.

SECT. III. *Of Stones in the Urethra.*

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Symptoms
of stones in
the urethra.

THOSE who are troubled with calculous complaints frequently pass small stones along with their urine; and when these are angular or of considerable size, they sometimes stick, and give much uneasiness. The symptoms are at first pain, then inflammation and swelling, attended with a partial, or total suppression of urine, which, if long neglected, is apt to terminate in a rupture of the urethra, when the urine will be discharged into the neighbouring parts. The greatest attention is therefore necessary to get the stone extracted as soon as possible.

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Method of
extracting
them.

When a stone is in the urethra, unless it be of a large size, or has been long impacted, and the inflammation great, attempts ought to be made with the fingers to push it out; but previous to this, the penis should be relaxed as much as possible, so as to remove a certain degree of spasm which the presence of stone here probably creates. Blood ought to be drawn by general or local means, according as the patient may be of a plethoric or emaciated habit. He should be immersed in a warm bath, and get a full dose of laudanum, and warm oil ought also to be thrown into the urethra. After these remedies have relaxed the parts as much as may be, the extraction is to be attempted.

For this purpose certain instruments have been contrived, particularly a tube containing a pair of elastic forceps (fig. 89.), to be introduced into the urethra so as to lay hold of the stone. In some cases they certainly might answer the purpose, but they have not been found very useful; and as they may increase the irritation already present in the urethra, they are seldom, if ever, employed. Instead of them, the surgeon uses gentle pressure on the penis to push the stone outwards; and as calculi larger than a field bean have sometimes been passed by the urethra, an operation ought not to be performed till gentler means have been persisted in for some time. When these means have failed, an incision ought to be made immediately upon the stone, which is then to be removed by a probe, or with a pair of small forceps. When a stone is lodged near the neck of the bladder, after the patient has been placed and secured in the same manner as for the lateral operation, while an assistant supports the scrotum and penis, the operator introduces a finger oiled into the anus, to support the stone in its place, and prevent it from slipping into the bladder. An incision is then to be made, and the stone turned out. The after treatment will be nearly the same as that after the operation of lithotomy.

When, again, a stone has advanced further in the urethra, the best method is to draw the skin strongly forwards or backwards, and then to cut upon it and turn it out, when the skin will slide back so as to cover the wound, and prevent the urine from passing through it; and by this means it will generally heal by the first intention. If part of the urine pass through the wound, and insinuate into the cellular substance, an attempt is to be made with the hand to press it back. If that prove insufficient, a cut is to be made through the skin opposite to the incision of the urethra; but this will seldom be found necessary. If a stone is fixed near the point of the urethra, it may be removed with a pair of forceps; or, if this fail, the urethra is to be dilated with a scalpel; and if this also be insufficient, an incision is to be made as above directed. When the cure is nearly completed, a tube formed of silver or elastic gum, or a hollow bougie, may be used to keep the urethra of a proper size.

The worst part of the urethra for a stone to stick in is that immediately behind the scrotum; for then the urine is apt to pass by the incision into the cellular substance of the scrotum, so as to occasion large swellings there. To prevent this, a stone so situated ought, if possible, to be pushed forwards with the fingers; or if this be impracticable, it should be pushed back into the perinæum by means of a staff. If both methods fail, a cut is to be made at the under part of the scrotum, which is to be well supported, and at one side of the septum, and continued upwards till the stone is felt, when an incision is to be made into the urethra, and the stone extracted as before directed.

CHAP. XXVIII. *Of Incontinence and Suppression of Urine.*

INCONTINENCE of urine may arise from various causes, as, from a loss of power in the sphincter of the bladder, while the natural tone of that organ remains unimpaired; or from irritation about the neck of the bladder, produced by the friction of stones contained in it; or from a laceration of parts by the operation of lithotomy; or from the pressure of the uterus in a state of pregnancy.

When the disease is owing to a want of tone in the sphincter, the cure is very difficult, because the constitution in general is frequently affected. The most useful remedies are tonics, especially peruvian bark, chalybeate waters, and the

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of Urine.

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the cold bath, both generally and locally applied. Cold substances applied to the perinæum are perhaps of greater service than any thing else, as cloths wet with vinegar and cold water, or with a strong solution of saccharum saturni in vinegar; but the best method of applying cold is to dash water immediately from the fountain upon the anus and perinæum. When it arises from the irritation of stones in the bladder, opiates and mucilaginous liquors plentifully used frequently give great relief. When incontinence of urine is owing to a laceration of parts in performing the operation of lithotomy, the disease is nearly of the same nature as that from the cause first mentioned, and therefore the same remedies are of service. When these remedies fail in either of the cases, compression of the urethra prevents any inconvenience arising from the constant dripping of the urine; and for this purpose an instrument termed *jugum penis* (fig. 90.) is applied to the penis; or, to press against the urethra of the female, pessaries (fig. 91. *a* and *b*) are contrived, which are made in such a way as to be introduced into the vagina, and there to press upon the urethra. They are sometimes made of sponge, but those of ivory or wood well polished are more generally preferred. A small bottle made of elastic gum, and open at both ends for the passage of the menstrual discharge, answers the purpose equally well. Certain cases however occur where pressure upon the urethra is improper, especially where there is a constant desire to pass water; and here much relief is obtained from the use of receivers, which are now suited to both sexes. Fig. 92. represents one for the male, and fig. 93. one for the female.

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Of su pres-
sion of u-
rine.

We shall here treat only of that species of suppression of urine where the urine is collected in the bladder, but from some obstructing cause is prevented from being discharged. It arises from a variety of causes.

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Treatment
when it a-
rises from
want of
tone in the
body of the
bladder,

When it arises from a want of tone in the body of the bladder, it is often connected with palsy of the lower extremities; it is frequently owing also to retaining urine too long. The catheter, in this case, is commonly an effectual remedy, and ought to be employed as soon as the suppression is evidently formed, and repeated from time to time, till the tone of the system is recovered by the use of proper remedies. The method of introducing the catheter is the same with that already directed for sounding for the stone. Fig. 94. a catheter for the male, fig. 95. one for the female.

When the affection arises from spasm about the neck of the bladder, opiates, warm water thrown into the rectum, and afterwards the warm bath, are the best means of producing relief. When it proceeds from scirrhus of the prostate gland, or from other tumors, or from obstructions of the urethra in consequence of gonorrhœa, the treatment to be afterwards described will be found best suited for such complaints. When the suppression arises from the pressure of the uterus in the latter months of pregnancy, change of posture is sometimes found to have some effect; but if this fail, immediate relief can commonly be given by the introduction of the catheter, which in women is for the most part readily done.

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From in-
flammation
of the neck
of the blad-
der.

Suppression of urine from inflammation affecting the neck of the bladder is one of the most alarming varieties of the disease, as it produces pain, and such a degree of swelling in the parts as to render the introduction of the catheter inadmissible. It may arise from the matter in gonorrhœa passing backwards along the course of the urethra. An improper use of injections has likewise frequently produced this species of the disease. The treatment is nearly the same as for inflammatory complaints in other parts of the body. Blood-letting should be employed, and particularly

leeches should be applied to the perinæum. Opiates ought to be given in large doses. Injections of warm water should be frequently thrown up the rectum, and the whole body should be immersed in the warm bath. If these means be properly used, they will very seldom fail of success; but when they do not prove effectual, when the bladder becomes painfully distended, and when every attempt to introduce the catheter has failed, nothing is to be depended upon but a puncture made into the body of the bladder, in order to discharge the water contained in it.

Various methods have been proposed for effecting this operation. Puncturing the bladder above the pubes has been recommended by many respectable authors. The following is the method of doing it: A lancet-pointed trocar, about two inches long, is to be at once introduced through the integuments, about an inch and half above the pubes, into the body of the bladder. The filette is to be removed as soon as the water begins to flow through a groove formed in it, and the urine allowed to flow through the canula, which is secured to the body by means of a bandage. A cork is to be fitted to the canula, that the urine may pass off at intervals only. The canula is to be retained till the cause which produced the obstruction is so far removed that the patient can discharge the urine in the natural way. It ought to be removed every three or four days, and cleared from the fordes which adheres to it, otherwise it soon becomes covered with a calculous crust, which renders the extraction exceedingly difficult. On these occasions a firm probe, of sufficient length, ought to be passed through it into the bladder, upon which it may again be easily returned as soon as it is properly cleaned.

This method of puncturing the bladder is not altogether free from objections: the bladder being suspended for a long time on the canula, its tone is sometimes destroyed; and if it happen to slip off the canula, the operation must be repeated; besides, the urine may be diffused in the surrounding cellular substance.

When the bladder is to be punctured from the perinæum, the trocar, which ought to be longer than the one for puncturing above the pubes, is to be introduced at a little distance from the rapha perinæi, and then passed into the body of the bladder, a little to the upper and outside of the prostate gland, carrying the point of the instrument a little upwards, to avoid wounding the ends of the ureter or seminal vessels. Puncturing from the anus, or the vagina in females, are attended with so many inconveniences that they ought never to be attempted.

CHAP. XXIX. Diseases of the Penis.

SECT. I. Of Obstructions of the Urethra.

OBSTRUCTIONS of the urethra frequently occur after repeated or severe attacks of the venereal disease. They may be owing to caruncles or fleshy excrescences in the urethra; to tumors in the lining membrane, or parts contiguous to the urethra, in consequence of inflammation; to spasmodic affections of the urethra; or to strictures properly so called.

Till of late years almost every instance of obstruction in the urethra has been attributed to caruncles, but their occurrence is much less frequent than was formerly imagined. They are rarely found except near the point of the urethra. They are considered to be nearly of the same nature with the warts which grow upon the prepuce or root of the glans in venereal cases. Tumors obstructing the passage in the urine may be occasioned either immediately by inflammation, or in consequence of old sores within the urethra;

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tions of the
urethra.

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Urethra.

thra; or tumors, from whatever cause, may be seated in the corpora cavernosa contiguous to the urethra, and may press upon it in such a manner as to cause an adhesion of its sides, and thereby produce stoppage of the urine. Spasmodic strictures of the urethra sometimes arise from stone in the bladder. Sometimes in gonorrhoea there is such a degree of contraction that neither staff nor bougie can enter. This variety of obstruction is known by its coming on suddenly, and going off sometimes almost completely in the space of a few hours. Of the permanent stricture, or stricture properly so called, Mr Hunter observes, that in most of the cases of this kind which he has seen the disease extends no farther in breadth than if the part had been surrounded with a piece of packthread. He has however seen the urethra irregularly contracted for above an inch in length, owing to its coats or internal membrane being irregularly thickened and forming a winding canal. He farther observes, that a stricture does not arise, in all cases, from an equal contraction of the urethra all round; but in some, from a contraction of one side, which throws the passage to the opposite side, and often makes it difficult to pass the bougie. In some few cases, he says, there are more strictures than one; he has seen half a dozen in one urethra, and finds that the bulbous part is much more subject to strictures than the whole of the urethra besides; that they are sometimes on this side of the bulb, but very seldom beyond it; and that they are often slow in forming, it being frequently years from the time they are perceived before they become very troublesome. Contrary to the opinion of others, Mr Hunter doubts very much if the stricture commonly, or even ever, arises from the effects of the venereal disease, or the method of cure; for strictures are common to other passages, and sometimes happen in the urethra where no venereal complaint had ever been.

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cure.

When obstructions are occasioned by caruncles in the urethra, bougies (fig. 96.) should be introduced rubbed over with bland oil until a resistance is met with. When a bougie cannot be introduced far enough, one with a smaller point is to be used, but not till the day following, lest the part be too much irritated. They ought not to be allowed to remain long at first, particularly when they occasion a considerable degree of pain.

When suppression of urine arises from swellings in or about the urethra, in consequence of inflammation, an attempt should be made to disperse these immediately, or bring them into a state of suppuration, and discharge the pus as soon as it is formed. But when the nature of the tumor is such as not to terminate in either of these ways, extirpation of the diseased parts, when this is found practicable, is the only probable means of relief. Bougies should at the same time be used to assist in the cure.

When spasmodic affections are present in the urethra, the remedies to be employed are, warm emollients, as rubbing the part with warm oil; anodynes, as opium given by the mouth, but more especially by the anus; blood-letting in plethoric habits, and this to be generally and locally applied; blisters put to the penis or perinæum; electricity, after plethora has been removed. Some cases may be treated with bougies; but where the disease is purely spasmodical, they are generally found to be hurtful; though in other cases, when the violence of the disease is so far removed, if they can be introduced, they are of service, by relieving any obstructions which may remain after the remedies above-mentioned have been exhibited. Costiveness ought likewise to be guarded against. The permanent stricture is to be cured by bougies.

Bougies act solely by pressure, and by supporting the part; hence they should be so large as to fill the passage,

and sufficiently flexible to be easily introduced. They are formed of various materials, as a composition of diachylon plaster, oil, and wax melted and put upon linen, which is afterwards properly rolled up; or they are formed of leather catgut, &c. properly prepared: but the best of any are those which are formed of elastic gum. Bougies, when properly made, can sometimes be kept in for six or eight hours together; but the length of time proper for their retention must depend much upon the feelings of the patient. At all times when they give much pain they ought to be removed, and not introduced again till the part is in a state fit for receiving them. They should be gradually increased in their size, till the passage returns to its natural dimensions. They ought to be continued for some time after, till it appear that there is no danger of a return of the complaint.

SECT. II. Of Phymosis and Paraphymosis.

In phymosis the prepuce is thickened, and contracted before the glans, so that it cannot be readily drawn behind it. In some people there is a constitutional phymosis from the natural straitness of the prepuce. Sometimes it arises from the matter secreted by the odoriferous glands at the root of the glands being confined and becoming acrid; sometimes from an anasarcaous swelling of the scrotum and penis; but most frequently from venereal virus.

The cure must depend upon the nature of the cause producing the disease. If the symptoms be inflammatory and of no long continuance, fomenting the parts frequently with warm emollient decoctions, or bathing them in warm milk, and then applying emollient poultices, or keeping the diseased parts constantly moist with a cold astringent solution, and turning the penis upwards and supporting it against the belly, commonly give relief. If the inflammation has arisen from a venereal cause, part of the fluid ought frequently to be injected, by means of a syringe, between the prepuce and glans, so as to wash off any matter which may there be concealed; but if the inflammation still continues to increase, blood-letting is necessary, both general and local. The veins of the penis are sometimes advised to be opened with a lancet; but this is unsafe on account of the nerves. Leeches may be applied; but care must be taken, in venereal cases, lest the bites of these animals, by absorbing venereal matter, turn into chancres. Along with the remedies already advised, gentle laxatives, low diet, and abstinence, ought to be prescribed. But if, after a due perseverance in these means, it is found that they have had little effect in removing the disorder, or perhaps that the symptoms are constantly increasing, and that chancres are confined under the prepuce; in that case it is necessary to slit open the prepuce, which is best done by a sharp-pointed bistoury, concealed in a grooved director, fig. 98. This is to be introduced between the prepuce and glands, till the director is found by the finger to have reached the upper or back part of the prepuce. The operator is now to keep the director firm with one hand, while with the other he pushes forward the knife, till its point passes through the prepuce; then drawing the instrument towards him, he cuts the prepuce through its whole length.

The operation being performed, the parts are to be washed and cleaned with warm water, and the fore dressed with a little soft lint, and a compress of linen laid over it. The whole may be retained by a small bag properly adapted, and secured by two straps to a bandage put round the body. This bag may be left open at the under end, to allow the patient to make water, without removing the dressings; but if this be found impracticable, the dressings may be removed with little inconvenience. If the glans be

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Phymosis and Paraphymosis. much inflamed and excoriated, care should be taken to insert lint spread with emollient ointment between the glans and prepuce, otherwise troublesome adhesions are apt to ensue. It is evident, that when this disease is of the venereal kind, the sore will not readily heal till the poison be eradicated from the constitution.

In some cases of phymosis the preputium is so remarkably long, and the contraction so much confined to the point, that a circular incision is preferable to a longitudinal one; and it is easily effected, by separating such a portion as may be found necessary of the whole circumference of the prepuce. The dressings in this case are the same as when the prepuce is slit open.

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Of para-phymosis. Paraphymosis is the reverse of phymosis, being formed by a retraction of the prepuce, producing stricture behind the glans of the penis. Like the former disease, it arises most frequently from a venereal infection, but may be produced from whatever preternaturally enlarges the glans or constricts the prepuce.

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Treatment. In the incipient state, the patient may generally be relieved by the surgeon pushing the glans gently back with his thumbs, while with his fingers he brings the prepuce gradually forward. But a more effectual method than this is to inclose the glans with one of the hands, and press gently on all sides, by which the fluids forming the enlargement will be pushed into the body of the penis behind the stricture. If this method be persevered in for a considerable time, it will generally be found to answer the purpose: but should it prove ineffectual, we may try the effects of cold applications; and the best seem to be those of the saturnine kind. When the penis is evidently much swelled and inflamed, the patient should be kept cool, gentle laxatives and low diet should be prescribed, and a number of leeches applied to the penis. Should the disease still continue to increase, and an œdematous swelling appear about the under part of the prepuce, an operation is necessary to prevent a mortification from taking place in the glans. An incision is to be made on each side of the penis immediately behind the glans, so large as completely to divide the stricture. The wound ought to be allowed to bleed freely; after which a pledget spread with simple ointment is to be applied, and an emollient poultice laid over the whole.

SECT. III. *Of an Incomplete Urethra.*

In children, especially males, the urethra is sometimes incomplete, ending before it reaches the usual place of termination. Sometimes it does so without any external opening, at other times it opens at a distance from the common termination. In the first case, a small trocar is to be introduced in the direction the urethra ought to take, till the urine be discharged; after which, the passage is to be kept open by the use of bougies, till the sides be rendered callous and an opening preserved. In the other case, as the opening which is already found affords a temporary passage for the urine, it will be better to delay doing any operation till the patient be farther advanced in life, when it is to be performed as in the former case.

After the operation, a piece of flexible catheter may be introduced, as well for the purpose of rendering the passage free and callous, as for carrying off the water till a cure is made.

SECT. IV. *Of Amputating the Penis.*

THIS operation is found necessary in certain diseases which will not yield to other remedies; as in cases of mortification and cancer. The following is the method of performing it:

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A circular incision is first to be made through the sound skin a little beyond the diseased parts; the skin is then to be drawn back by an assistant, and the body of the penis divided by one stroke of the knife (fig. 99.) immediately at the edge of the retracted skin. The principal arteries, which are two or three on each side, are next to be secured by ligatures; and if an oozing of blood still continue, the surface of the sore ought to be dusted with some styptic powder. To allow the patient to make water, a silver canula (fig. 99. a) is to be introduced into the urethra, and retained there by two small ligatures fixed to the side of the canula, their other extremities being fastened to a bandage put round the body. The wound is to be dressed with soft lint, kept in its place by a piece of linen previously perforated for the introduction of the canula. The dressings are to be kept on by a narrow roller passed a few times round the penis, which, by gently compressing the penis upon the instrument, will effectually prevent any farther discharge of blood. The after treatment of the sore should be similar to wounds in other parts of the body. But it will not be necessary to make any farther compression of the penis upon the canula, as the discharge of blood will, previous to this time, be entirely stopped. The tube is to be allowed to remain in the urethra during the whole time of the cure.

Before any operation of this kind is attempted, the surgeon ought to examine attentively, whether the disease be in the penis itself, or only in the skin, as the prepuce alone is frequently so much enlarged and otherwise diseased as to give cause for suspicion that the glans and body of the penis are likewise affected. This precaution is the more necessary, as several instances have occurred where the glans and body of the penis have been removed, and, after the operation, have been found perfectly sound. Previous to amputation, therefore, where there is any cause for suspicion, the prepuce should be slit open, and the glans examined, so as to avoid amputating more than what is absolutely diseased.

It sometimes happens that the frænum of the penis is so short as to give considerable uneasiness in time of an erection. When this is the case, it may be safely divided by a pair of scissors, or by a sharp-pointed bistoury, and the wound dressed with a little charpie.

SECT. V. *Of Fistula in Perinæo.*

THE term implies a sinuous ulcer in the perinæum, commonly communicating with the urethra, but sometimes opening into the bladder. The same term is also applied to similar sores opening into the scrotum, or into any part of the penis.

The disease may arise from wounds in the bladder, and of the urethra, from external violence; from a laceration of parts when performing the operation of lithotomy; from incision into the urethra for the extraction of calculi impacted there; from sinuses producing matter capable of corroding the membranous part of the urethra; from suppuration in the perinæum in consequence of inflammation; from the urine passing through an opening in the urethra into the perinæum or other neighbouring parts, and rendering the edges of the sore callous; and most frequently the disease is occasioned by venereal complaints.

In the treatment of this disease, when it is the consequence of a general affection of the system, a removal of the primary disorder is necessary before a cure can be attempted. When the complaint is of a local nature, a simple incision into the sinus is all that is necessary; and for this purpose a staff is to be introduced into the urethra, so as to pass the opening at which the urine is discharged. A probe, or a small director, is now to be passed at the external opening of the

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Of shortness of the frænum.

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Causes of fistula in perinæo.

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Treatment.

Hemorrhoids or Piles.

the sore till it reach the staff; and cutting upon it, the sinus is to be laid open through its whole length till it terminate either in the urethra, or, if necessary, in the bladder itself. When more openings than one are present, they are to be treated in the same manner; and if the sinuses are found to be remarkably hard, the removal of a small portion of the diseased part will expedite the cure, though the consequent inflammation and suppuration will render this seldom necessary. After the operation, the wound is to be dressed with pledgets of emollient ointment, so as to allow it to fill up completely from its bottom. The whole is to be covered with a pledget of emollient ointment; and proper compresses being applied over it, the dressings are to be supported by a T bandage.

If symptoms of inflammation be violent, an emollient poultice is to be applied in the course of twenty-four hours after the operation; and as soon as free suppuration is formed, light easy dressings are to be used till the sore is completely healed.

CHAP. XXX. Diseases about the Anus.

SECT. I. Of Hemorrhoids or Piles.

THE treatment of piles has been already considered under the article MEDICINE; but it sometimes happens, that although the means mentioned there have been employed, the disease becomes so violent as to require the assistance of the surgeon. Where the discharge of blood is so great as to endanger the life of the patient, we ought to attempt to stop it either by compression, or by securing the bleeding vessels by a ligature; and here the tenaculum is preferable to the needle, because, when the latter is used, a portion of the rectum is apt to be included in the ligature. When piles arrive at such a size as to obstruct the passage of the feces, or to produce great irritation, the removal of them by the knife or by ligature becomes necessary. The first of these may be used when their size is of such a nature as not to threaten a dangerous hemorrhagy; but when this is the case, they ought to be removed by ligature, the manner of applying which has been considered under the treatment of *Polypi*. The dressings are to be of a simple nature.

SECT. II. Of Condylomatous Excrescences, &c. of the Anus.

EXCRESCENCES are sometimes produced about the anus, which from their figure get the name of *fici*, *aristæ*, &c.; but they are all of the same nature, and to be cured by the same means. They sometimes grow within the gut itself, but more frequently are situated at the verge of the anus. They vary considerably in their colour, figure, and consistence. Sometimes they are only one or two in number, but commonly all the skin about the anus becomes covered with them. They vary in size from that of ordinary warts to that of split garden beans. They seem originally to be productions of the skin, though at last they sometimes proceed as deep as the muscles. They frequently remain long without producing much uneasiness. When this is the case, they ought not to be touched; but sometimes they become so troublesome as to render their removal necessary.

The softer kinds can frequently be removed by rubbing them often with gentle escharotics, as crude sal ammoniac, or pulvis sabinae; but the harder kinds are to be removed chiefly by lunar caustic, or by the knife; the latter of which is greatly preferable, and may be done with the utmost safety.

The sores are afterwards to be treated like wounds pro-

duced by any other cause. If caustic is to be used, care ought to be taken that it do not injure the rectum.

Fistula in Ano.

SECT. III. Of Fistula in Ano.

THE fistula in ano is a sinuous ulcer in the neighbourhood of the rectum. When it opens externally, and has likewise a communication with the gut, it is termed a *complete fistula*; but if it has no communication with the rectum, it is called *incomplete*. When the ulcer communicates with the gut, but has no external opening, it is named an *internal* or *occult fistula*. It is likewise distinguished into simple and compound. The first is where one or more sinuses communicate with the internal ulcer, but where the parts in the neighbourhood are found. The compound fistula is where the parts through which the sinus runs are hard and swelled, or where the ulcer communicates with the bladder, vagina, os sacrum, and other contiguous parts.

The causes producing the disease may be, whatever tends to form matter about the anus, piles, condylomatous tumors, hardened feces, or any cause which produces irritation and inflammation, so as to end in suppuration. As soon as a swelling about the anus appears to terminate in suppuration, every thing ought to be done which can accelerate the formation of matter. A proper degree of heat, warm poultices, fomentations, and the steams of warm water, are the means best suited for this purpose; and as soon as matter is formed, it ought to be discharged by a free incision in the lowest part of the tumor. Much depends upon the proper treatment here; for if the opening be made too small, or if long delayed, the matter gets into the loose cellular substance, and instead of producing one, produces many sinuses, and these sometimes running to a great depth. The parts ought then to be covered with soft lint spread with mild ointment, and an emollient poultice kept constantly over the whole. By this any remaining hardness will be removed, the cavity will fill up like imposthumous tumors in other parts, and a complete cure will in general soon be made.

It more frequently happens, however, that the practitioner is not called in till the abscess has burst of itself, and till matter has insinuated into the surrounding cellular substance, and formed one or more real fistulae.

The first thing to be done now is to discover the real course of the different sinuses, and the probe is the best instrument for this purpose. If there be openings in the external surface, there is commonly little difficulty in this. If they run along the perinaeum or the muscles, the probe will generally detect them. If they follow the direction of the gut, the best method is to introduce the fore finger oiled into the rectum, while the probe is entered at the external orifice. If there be a communication between the gut and the sinus, the probe may be made to pass till its point is felt by the finger in the rectum. We discover with certainty if a sinus communicate with the gut, when air or feces are discharged, or when any mild fluid injected returns by the anus.

After the course of the sinus has been discovered, the method of cure is next to be considered. Astringent or escharotic injections, pressure, and setons, are insupportable, on account of the violent pain which they produce. The only method therefore of bringing on a proper degree of inflammation is a free incision along the whole course of the sinus. The course of the different sinuses having been previously discovered, a laxative ought to be given on the day preceding this operation, and a clyster an hour or two before performing it. The patient is to be placed with his back

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Causes of
Fistula in
Ano.

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Treatment
during the
first stage
of the
simple fi-
stula.

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Treatment
after sinuses
are formed.

Fistula in Ano. back towards a window, while his body leans upon a bed, table, or chair. The finger of the surgeon is to be rubbed over with oil, and introduced into the rectum. The end of a crooked probe-pointed bistoury (fig. 100.) is then to be passed into the fistula, and pushed against the finger in the rectum, if the fistula be complete. But in cases of incomplete fistulæ, the point of the instrument must be made to perforate the gut before it can reach the finger. Some make the perforation with a sharp-pointed bistoury, which can be made to slip along the side of a probe-pointed one, as at fig. 101. After the bistoury has reached the cavity of the rectum, the point of it is then to be brought out at the anus, and a cut made downwards to lay the sinus completely open. In this operation the sphincter ani muscle is commonly cut, if the sinus be high; but no inconvenience is found to arise from this circumstance. It sometimes, though rarely, happens, that the sinus goes beyond the reach of the finger, and even as high as the upper end of the sacrum. The only thing which can be done in this case is to cut as high as the finger can go, so as to give a free and easy vent to the matter.

Some practitioners, with a view to prevent troublesome hemorrhagies, and others to free the patient from the dread of the knife, have proposed to open the sinuses by means of ligature (fig. 102.). By introducing one end of a piece of silver or leaden wire into the sinus, then bringing it out at the anus, and twisting the ends together, the contained parts may be so compressed as to produce a complete division of them. But this is both more painful and tedious than the scalpel, and appears to be by no means necessary.

356 Method of discovering the presence of an occult fistula. When the presence of an occult fistula is suspected, its existence ought first to be fully ascertained, by examining whether the matter which is passed by stool proceeds from an ulcer in the bowels or from an abscess at the side of the anus. It is discovered by matter from the bowels being mixed with the feces, and no pain about the anus. In occult fistula, a hardness, swelling, and discoloration, are observed upon some spot near the anus, and there is a sensation of considerable pain upon pressure being made upon it. The operation in this is the same with that in the other two varieties of the disorder; only that an opening is previously to be made, by a lancet or scalpel, in that spot where the matter appears to be lodged. By this the fore will be reduced to a complete fistula, and the rest of the operation will be easily performed.

357 Treatment in compound fistula. In this manner the different sinuses are to be operated upon, when in a simple state; but in those of a compound nature, where the parts in the vicinity of the fores have been separated from each other by an effusion of matter into the cellular substance, and where all the under end of the rectum has, in some rare cases, been attached from the surrounding parts, two modes of operating have been recommended; either to remove a considerable portion of the external integuments, so as to give free vent to the matter; or to extirpate all the lower end of the rectum which is found to be detached from the surrounding parts. But from the pain and subsequent distress which they occasion, these methods are judiciously laid aside. All that is necessary to be done here is to lay the detached portion of gut completely open, as in cases of simple fistulæ; but if this be insufficient for allowing the gut to apply properly to the contiguous parts, another incision should be made on the opposite side. If the neighbouring bones be found sound, and the constitution in other respects be unimpaired, a complete cure will probably be obtained.

The matter sometimes insinuates itself between the skin and muscles of the perinæum, or of the hip. When this is observed, the sac produced by it should be laid open from

one end to the other by one or more incisions as circumstances may require. Sometimes, from neglect or improper treatment, the matter collected does not find a proper outlet, and then the parts most contiguous to it inflame, become painful, and gradually acquire such a morbid callosity as to put on a scirrhus appearance. In such cases a cure may be effected by giving free vent to the matter, preventing every future collection, and inducing and preserving a suppuration in the substance of the parts chiefly affected. To accomplish this last circumstance, however, it may sometimes be necessary not only to lay the sinuses freely open, but to cut in upon the obdurate parts.

358 Treatment after laying open the sinuses. The different sinuses having been laid open, care must be taken to apply the necessary dressings. Upon this much of the success attending the operation depends. Dry lint, till lately, was much used by practitioners; but it has been found to produce so much irritation, especially when too much crammed in, as to be one of the causes of that diarrhoea which is frequently so troublesome after operations of this kind. Instead, therefore, of this sort of dressing, pledgets, lint, or soft old linen spread with any simple ointment, are to be preferred. After the fores have been cleared from clotted blood, the pledgets are to be gently insinuated between their edges, but not to such a depth, or with such force, as to give any uneasiness. This being done, and a compress of soft linen with a T bandage being applied over the whole, the patient is to be carried to bed; and the dressings being renewed, either after every stool, or, when these are not frequent, once in the twenty four hours, the fores will generally fill up from the bottom, and will at last cicatrize in the same manner as wounds in any other part of the body. Sometimes, however, they acquire a soft, flabby, unhealthy aspect, and the matter discharged from them is thin, fetid, and occasionally mixed with blood. These appearances may sometimes arise from some part of a sinus having been overlooked. In this case advantage may follow from the part being laid completely open. But it more usually proceeds from some affection of the general system; and till this is eradicated the fores cannot be expected to heal.

In the cure of fores in other parts of the body, practitioners have sometimes found great advantage to arise from the use of issues. The same thing is now found to be applicable here. Wherever therefore fistulæ are of long standing, while any disorder existing in the constitution is properly attended to, practitioners recommend, that an issue, in proportion to the quantity of the matter discharged by the fores, should be immediately employed. In this way, if the bones in the neighbourhood are not diseased, there will be reason to expect that a complete cure will be obtained.

SECT. IV. Of Prolapsus Ani.

THIS is a protrusion of part of the rectum beyond the anus. It is often occasioned by debility of the parts, but is most frequently owing to violent exertions made in the rectum in consequence of irritation. The reduction should be effected as soon as possible; for although this part of the intestine can bear exposure to air much longer than any of the rest, yet allowing it to remain a long time out would be attended with great uneasiness, and probably with danger. In the reduction, the tumor ought to be supported with the palm of one hand, while with the fingers of the other the part of the gut last protruded is to be returned. If the gut has been long exposed previous to the reduction, venesection may become necessary, and gentle astringents may be applied to the part. The patient during the reduction is to be kept in a reclined posture. As soon as the bowels

Imperforated Anus. are returned, a proper bandage (fig. 103.), is to be applied. Such remedies are afterwards to be exhibited as most tend to recover the tone of the parts.

SECT. V. *Of Imperforated Anus.*

THIS disorder, though not frequent, now and then occurs; and when present, unless speedy relief be given, must prove fatal. In some cases, the end of the rectum protrudes at the usual situation of the anus, and is only covered with the common integuments; but in others, no termination of that gut is discoverable. Sometimes the rectum ends within an inch of the usual seat of the anus; at others, it reaches no farther than the top of the sacrum. In some cases it terminates in the bladder; in others, in the vagina. In the most favourable cases, where the rectum protrudes, an opening may be readily made by a scalpel or lancet; but when no direction of this kind is met with, an incision is then to be made in the place where the anus is usually situated, and is to be continued in the direction of the os coccygis and sacrum, which is the course the intestine commonly takes. The finger is to be used as a director along it; the parts are to be cut either till faeces are observed, or till the incision has been made the length of the finger. If still the faeces do not appear, a lancet-pointed trocar is to be pushed forward upon the finger in such a direction as the operator thinks will most probably reach the gut. An artificial anus is likewise to be attempted, where the gut terminates in the bladder or vagina. After the operation, the greatest attention is necessary to preserve the opening which has been made. Substances which irritate least are the most useful; such as dossils of lint moistened in oil, and rolls of soft bougie plaster.—We shall conclude this chapter with two short sections of imperforated hymen and prolapsus uteri, though they do not properly come under it.

SECT. VI. *Of an Imperforated Hymen.*

WHEN the hymen is imperforated, the most troublesome symptoms, at a certain period of life, may be produced by the accumulation of that fluid, which ought to be discharged; for then a tumor is formed, by which the most violent bearing-down pains are occasioned. These increase in severity to such a degree, as sometimes to be mistaken for labour-pains. They disappear, however, during the intervals of the accustomed periods. In the treatment of this disease, all that is necessary is to make either a single or a crucial incision into the obstructing membrane, and then to prevent the accretion of its edges by dossils of lint spread with some emollient ointment till the parts are healed.

SECT. VII. *Of Prolapsus Uteri.*

THIS is a falling down of the uterus, occasioned by debility or by excessive straining in the time of parturition. The disorder seldom occurs before child-bearing, and is commonly met with in those who are somewhat advanced in life. The parts protruding are to be reduced by gentle pressure, while the patient is put in an horizontal posture. Pessaries (fig. 91. *a* and *b*) are to be employed, which ought to be made of the lightest materials, finely polished, and somewhat compressible; and none possess these qualities in a more perfect degree than a pessary made of the elastic gum-bottle. This, or whatever else may be used to answer the purpose, is to be retained by a proper bandage till by tonic medicines the parts recover strength to retain their natural situation.

CHAP. XXXI. *Of Luxations.*

SECT. I. *Of Luxations in general.*

A BONE is said to be luxated when that part of it form-

ing a joint is moved out of its place. When the bone is forced entirely out of its cavity, the luxation is termed *complete*; when this is not the case, it is *partial* or *incomplete*. When there is also a wound of the soft parts communicating with the joint, it is called a *compound*, and when there is no wound, a *simple luxation*.

The common symptoms of a dislocated bone are, inability to move the injured limb; pain, tension, deformity in the part affected; and sometimes inflammation, subsultus tendinum, and fever: and these three last are greatest in partial dislocations. The swelling which first appears is always inflammatory; but afterwards a secondary swelling comes on, seemingly cedematous, and probably owing to the pressure of the lymphatics by the dislocated bone.

In judging of the practicability of reducing a luxation, we ought to attend to its nature and extent, the other circumstances with which it may be complicated, and the length of time which it has continued. When a bone is only partially dislocated, it is evident that it may be reduced with much more ease and certainty than where it is completely displaced. It is evident also that fracture attending dislocation must render reduction much more difficult and uncertain. Indeed, when both the bones forming the joint are broken, there is the greatest hazard of its remaining stiff during life, even when the greatest attention has been paid. Luxated bones are most easily reduced immediately after they are displaced: the difficulty indeed of reducing them is generally proportional to the time that has intervened since the accident happened. When a bone has been some time lodged among the contiguous muscles, it forms a socket for itself, and is firmly grasped by the surrounding soft parts. The cavity, too, from which it was dislodged may be partially filled with some of the surrounding soft parts, or at least diminished by the constant action of the contiguous muscles on its cartilaginous brim. Dissections, however, show, that inspissated synovia does not, as was formerly supposed, fill up this cavity. In delicate constitutions and advanced periods of life, when the muscles give little resistance, dislocations are more easily reduced than in the vigour of youth or in robust constitutions.

In the treatment, we ought, 1. To reduce the dislocation with as much ease and expedition as possible; 2. Retain the bone in its situation till the parts have recovered their tone; and, 3. Obviate all uneasy symptoms.

1. When the surrounding skin and muscles are much contused and inflamed, we should endeavour to remove the inflammation by local bleeding, saturnine applications, and laying the limb in an easy posture, before we attempt to reduce the bone, as considerable injury may be done by stretching a limb while the parts surrounding the joint are inflamed. The upper part of the limb should be kept steady while the surgeon endeavours to replace the under bone, which alone is commonly displaced. This is not easily done; for the contractile power of the muscles acts strongly against every attempt, and not only draws it beyond the contiguous bone against which it should be placed, but frequently forces it out of its natural situation, and fixes it firmly in some neighbouring cavity, from which it is with difficulty removed. To prevent this resistance as much as possible, the muscles ought to be put into a state of relaxation. If this is properly done, the force necessary for reducing a luxated bone may generally be obtained from assistants alone; sometimes, however, machinery is required, and various instruments have been invented for this purpose. Freke's machine is the most generally used. The force ought always to be applied in a gradual manner, and to the dislocated bone alone, and not to any more distant parts of the limb. After the end of the dislocated bone is brought into a line with that to which it

Luxations of the Bones of the Head and Neck. is opposed, the reduction is easily completed either by the action of the muscles alone, or, if that is not sufficient, by gentle pressure.

2. After the reduction there is seldom any difficulty in retaining the bone in its place, unless it has often been dislocated before. All that is necessary is to place the limb in a relaxed posture, and to support the bone with a bandage till the parts have recovered their tone.

3. The most urgent symptoms which accompany dislocations are, pain, inflammation, and swelling. These usually abate soon after the reduction. If any degree of inflammation remain, the use of leeches is the best remedy.

When dislocated bones are accompanied with fracture near the joint, the fracture must be allowed to heal before reduction be attempted. This, however, is not always necessary in very small bones, as those of the fingers. When the fracture is at a distance from the joint, the dislocation may generally be reduced immediately. Compound luxations are to be treated nearly as compound fractures. After the bone is replaced, leeches should be applied to abate the inflammation; after which the sore should be dressed with Goulard's cerate, or any other mild ointment, and the pain moderated by opiates and a low regimen: care ought also to be taken that no matter lodge about the joint. When luxations are produced by tumors or collections of matter in the neighbourhood of the joints, they may be considered as incurable: when they proceed from too great a relaxation of the ligaments and tendons of the joint, the bone can hardly be prevented from being now and then displaced; but the inconvenience may be somewhat obviated by supporting the limb with a proper bandage, by the use of the cold bath, and by electricity.

SECT. II. *Luxations of the Bones of the Head and Neck.*

363 **Luxations of the bones of the cranium.** If the bones of the cranium be separated by external injury, all that can well be done is, to support the parts by a bandage, to prevent inflammation, to keep the patient quiet, and in a proper posture during the cure. The bones of the nose are seldom luxated without fracture: when they are, the injury is easily discovered by the touch. When one of the bones is driven inwards, it may be raised and reduced by pushing a tube of a proper size, and covered with soft lint, into the nostril; which may be afterwards retained till there is no danger of the bone being again displaced. If the bone be luxated outwards, it may be reduced by the fingers, and retained by a double-headed roller. The lower jaw is luxated most frequently when the mouth is opened widely; it can only take place forwards and downwards, which are least surrounded by the neighbouring parts: both sides are generally luxated at once; and in that case the mouth is opened wide, the chin thrown forwards and towards the breast. When only one side is dislocated, the mouth is distorted, and widest on the sound side of the jaw, which is drawn a little towards the contrary side. The patient should be seated, and his head supported. The surgeon should push his thumbs, protected by a covering of strong leather, as far as possible between the jaws, and then with his fingers, applied on the outside of the angle of the jaw, endeavour to bring it forward till it move a little from its situation. He should then press it forcibly down, and the condyles will immediately slip into their place. The thumbs ought to be instantly withdrawn, as the patient is apt to bite them involuntarily. The patient should for some time avoid much speaking or opening his mouth wide.

366 **Luxations of the head or neck.** When the head is luxated, it commonly falls forward on the breast, the patient is instantly deprived of sense and motion, and soon dies if the luxation be not quickly reduced.

In reducing the luxation, the patient should be placed on the ground, and supported by an assistant: the surgeon standing behind should gradually pull up the head, while the shoulders are pressed down by the assistant till the bones are brought into their place, which is known by a sudden crack or noise: if the patient be not dead, he immediately recovers his faculties, at least in some measure. He should then be put to bed with his head elevated and retained in one posture. He should lose a quantity of blood, and live for some time on a low diet.

SECT. III. *Luxations of the Spine, Os Coccygis, Clavicle, and Ribs.*

367 **Luxations of the vertebrae.** THE vertebrae are sometimes partially, but hardly ever completely, dislocated without fracture. When they occur high up, they are attended with the same symptoms as dislocation of the head: when farther down, besides distortion of the spine, paralysis ensues of every part of the body situated under the luxated bone; there is commonly also either a total suppression of urine, or it is discharged involuntarily together with the faeces. As luxations of this kind are generally owing to falls or violent blows, the displaced vertebra is driven either forwards or to one side; it is therefore very difficult to reduce it. The best, as well as the simplest method, is to lay the patient on his face over a cylindrical body, as a large cask, and at the same time to attempt to replace the bone with the fingers. If the bone be very much displaced, there is very little reason to hope for success. The os coccygis is more liable to dislocation than any other part of the spine. It is sometimes forced outwards in laborious births. This is discovered by the great pain which is felt at the connection of the os coccygis with the sacrum, and by the bone appearing to be displaced when examined. It may generally be easily reduced by pressure with the fingers. The best support afterwards is a compress, with the T bandage. When the coccyx is luxated inwards, the patient complains of severe pain, tenesmus, and a sense of fulness in the rectum; the faeces are passed with difficulty, and in some cases a suppression of urine takes place. The injury is easily discovered by introducing the finger into the anus. In this case the bone should be pressed outwards, by introducing the fore and middle fingers of one hand dipped in oil into the rectum, and supporting the parts which correspond with it externally till the reduction is accomplished. Dislocations of these bones are apt to excite inflammation, which often terminates in dangerous abscesses; it ought therefore to be guarded against by every means in our power.

369 **Luxations of the clavicle.** The clavicle is most frequently luxated at its junction with the sternum; because the violence which produces the injury is generally applied to the shoulder. The luxation is discovered by pain in the part, by the projection of the bone, and by the immobility of the shoulder. It is easily reduced by pushing the bone into its place with the fingers, while an assistant draws back the arms and shoulders. It is not so easy to retain the bone in its place. When it is the inner extremity of the clavicle which has been dislocated, the shoulder should be kept in its natural situation, neither raised nor depressed: the fore arm should be supported, as should also the head and shoulders, and a moderate pressure should be made upon the displaced end of the bone. For this purpose the machine represented fig. 104. the invention of Mr Park of Liverpool, answers best. But when the outer extremity of the clavicle has been dislocated, the shoulder must be considerably raised, the arm supported in a sling, and the bone kept in its proper situation by a small compress placed over its end, and secured by a roller forming the figure 8; or it may be retained by the machine.

Luxations of the Spine, Os Coccygis, Clavicle, and Ribs.

367 **Luxations of the vertebrae.**

368 **Of the os coccygis.**

Luxations
of the
Bones of
the Superi-
or Extre-
mities.

370
Of the ribs.

machine above mentioned. The bandage ought to be retained for a considerable time.

Luxations of the ribs are exceedingly rare. The symptoms are nearly the same with those arising from fracture, only that the pain is more severe at the articulation, and that no other spot but that will yield to pressure. All that can be done is to bend the body forward over a cask or some such body, in order to assist the viscera in pressing out the rib. Bandages are of little use. The patient should be kept quiet, and fed on a low diet: inflammation should be prevented, and opiates given if he has a troublesome cough.

SECT. IV. *Luxation of the Bones of the Superior Extremities.*

371
Luxation
of the head
of the os
humeri.

THE head of the os humeri is most frequently dislocated forwards and downwards, sometimes downwards and backwards, but never upwards without a fracture of that part of the scapula which is placed above the joint. The luxation is discovered by the patient's inability to raise his arm, by violent pain attending the attempt, by the luxated arm being of a different length from the other, by the head of the humerus being felt out of its natural situation, while a vacancy is perceived under the acromion, and by the flatness of the injured joint, while the sound one has its natural fullness. When the luxation is of long standing, the whole arm is apt to become oedematous.

372
Method of
reduction.

The patient should be seated on a chair, and his body secured by a broad belt passed round it, and held by assistants. The elbow should be bent, in order to relax the muscles on the fore part of the luxated joint. A firm leather belt four or five inches broad, with strong straps, and lined with flannel, is to be tied round the arm immediately above the elbow: assistants are to extend the arm gradually, by pulling these straps, while another assistant draws back the scapula. The surgeon stands on the outside of the arm, directs the assistants, and varies the direction of the extension, according to the situation of the head of the bone. As soon as the head of the bone has cleared the brim of the socket, the muscles draw it into its place, a crack is heard, the patient is relieved, and the anterior part of the shoulder acquires its usual fullness.

373
Various
methods of
extending
the arm.

Various other methods of extending the arm have been proposed in difficult cases; as, suspending the patient by the luxated arm over the step of a ladder or the top of a door, raising him up by the arm with ropes running over pulleys fixed in the ceiling of a room, &c. The jerk produced by the body being suddenly raised and let down again on a feather bed, has sometimes succeeded when other means have failed. A gentler method is to lay the patient on the floor, while two or three stout men standing on a table lay hold of him by the arm and pull him up. But all these methods are in danger of lacerating the soft parts by the suddenness with which the force is applied, and even sometimes of breaking the end of the humerus if it be pressed against the neck of the scapula. Mr Freke's improvement on the ambé of Hippocrates has been considered as the best machine for extending the arm. But machinery is very seldom necessary; even cases of long standing may by proper management be reduced by means of assistants, provided reduction be at all practicable. Inflammation after the operation should be obviated by the usual remedies. If the bone be apt to slip out again, which sometimes happens after repeated dislocations, the arm should be supported in a sling till the parts have recovered their tone. Blisters, friction, stimulating medicines applied to the shoulder, and cold water poured on it, have sometimes been useful in restoring the strength of the joint.

Luxations at the elbow most commonly happen upwards and backwards; and then the fore-arm is shortened, the end of the ulna projects behind, and is higher than usual, while the extremity of the humerus can be felt in the bend of the elbow. The surgeon should take hold of the wrist with one hand, and the upper part of the fore-arm (which is to be moderately bent) with the other, and gradually pull the top of the fore-arm downwards, while at the same time he increases the curvature of the elbow to disengage the ends of the bones from each other. He should then pull the bones forward into their situation. When the luxation happens upwards and forwards, it should be reduced while the arm is extended. After the reduction, the muscles of the fore-arm should be kept relaxed by bending the elbow a little till the parts have recovered their tone. When the bones of the fore-arm are dislocated from each other, which happens most frequently at the wrist, the rotatory motion of the hand is destroyed. After the reduction, the bones should be bound together by a tight flannel roller, or a couple of splints should be applied along the fore-arm, and the arm supported in a sling.

The bones of the wrist are not so often luxated as might be expected from the smallness of their size. When they are, great swelling and pain ensues, and the motion of the joint is entirely destroyed. Great attention is necessary, lest luxation should be mistaken for a sprain. The arm and hand should be supported by assistants, but not stretched; and then the bones should be pushed into their place, and afterwards retained by proper bandages and splints. The bones of the metacarpus, when they happen to be dislocated, which is very seldom, are to be reduced in the same manner. Dislocations of the thumb or fingers are easily discovered. To reduce them, an assistant should hold the phalanx from which the dislocation happened, while the surgeon endeavours to elevate the bone from the one contiguous to it, and to pass it into its place.

SECT. V. *Luxations of the Bones of the inferior Extremities.*

FROM the great strength of the hip joint, it was formerly believed that the head of the thigh-bone was never luxated by external violence; but it is now known that it happens by no means unfrequently. The ball in starting from its socket generally passes forwards and downwards into the foramen thyroideum. When this happens, the limb is considerably lengthened, the head of the bone is lodged near the under and fore part of the pelvis, the large trochanter is observed on the fore part of the thigh, a vacancy is perceived where the head of the bone and the trochanter should be, and the toes are turned outwards. When the bone is dislocated upwards and backwards, the limb is shortened, the great trochanter higher than usual, the knee and foot turned inwards. When it is dislocated upwards and forwards, the leg is shortened, the ball of the bone is felt on the os pubis in the groin, and the great trochanter on the upper and lower part of the thigh; a vacancy is discovered in the corresponding part of the hip; the knee and toes are turned outwards. When the ball slips downwards and backwards, the leg is lengthened, the toes turned inwards, and the great trochanter is lower than that of the other limb. If the ball slip directly downwards, the leg is lengthened, but the knee and toes keep nearly their natural situation. It is sometimes difficult to distinguish between luxation and fracture of the neck of the bone. In fractures the bone is most frequently pushed upwards, and the leg shortened, the knee and point of the toes are turned inwards, and may be moved much more readily outwards and inwards than when the bone is dislocated.

Luxations of the Bones of the Inferior Extremities. For reduction, the patient should be laid on a mattress on the sound side, and a wooden roller covered with several folds of flannel placed between his thighs, and fixed firmly by straps to the wall. A strong bandage of buff leather, or something similar, should be applied to the under end of the thigh, with straps fixed to it to make the extension. The trunk of the body should be properly secured, and the joint of the knee bent. The extension should be made at first gently, and increased gradually, while, at the same time, the thigh is made to roll in different directions. When the extension is sufficient, two assistants should lay hold of the roller, and attempt to raise the bone; the extending force should then be slackened, and the surgeon should push the head of the bone upwards and outwards, while an assistant presses the knee forcibly inwards. The muscles themselves will then commonly bring the bone into its place; and this is done with such a jerk and noise, that it is heard by the bystanders. If the reduction be not obtained, the extension must be repeated with greater force. Instead of the roller a broad strap or table cloth is frequently used. The limb should not be used for some time after reduction, and inflammation should be prevented by the proper remedies.

379
Luxation of the patella.

The patella can neither be luxated upwards or downwards, without rupture of the tendons of the extensors muscles, or of the strong ligament which fixes it to the tibia; but it may be luxated to either side. The luxation produces lameness, and much pain on attempting to move the joint. In recent cases the injury is easily discovered; but when the surgeon is not called immediately, the swelling may be so great as to render it more difficult. For reduction, the limb should be kept extended; the surgeon, by depressing the edge of the patella most distant from the joint, is enabled to raise the other, and push the bone into its place.

It may be necessary to remain a day or two in bed till the knee recover its tone. Sometimes, after the bone has been displaced, returns of the same complaint become frequent. In such cases, proper machinery applied to the side of the tumor, where the bone is apt to start out, is used with advantage.

380
Luxation of the tibia at the knee.

From the size of the joint, and the great strength of the ligaments, luxations of the tibia from the os femoris rarely occur. When it does, it is easily discovered by the pain, lameness, and deformity of the limb. The patient should be laid on a table, the muscles relaxed, and the thigh secured by assistants; the limb should then be extended, and the bones cleared of each other, when they will be easily replaced. After the reduction, the limb should remain for some time perfectly at rest; and inflammation, which is very apt to ensue, and is attended with very bad consequences, should be assiduously guarded against.

381
Luxation of the ankle-joint.

If the ankle joint be dislocated forwards, the fore part of the foot is lengthened; if backwards, the foot is shortened and the heel lengthened (this is the most common variety); if to either side, there is an uncommon vacancy on the one side, and a prominency on the other. Dislocation, however, can hardly take place outwardly without fracture of the end of the fibula.

For reduction, the limb should be firmly held by assistants, the muscles relaxed, and extension made till the bones are cleared of each other, when the astragalus will easily slip into its place.—The same rules should be observed in reducing dislocations of the bones of the foot. Luxations of the metatarsal bones and toes are reduced exactly in the same manner as the bones of the metacarpus and fingers.

CHAP. XXXII. Of Fractures.

SECT. I. Of Fractures in general.

THE term *fracture* is generally confined to such divisions in bones as are produced by external injury. When the integuments remain sound, the fracture is called *simple*; when it communicates with a wound, it is called *compound*.

The general symptoms of fracture are pain, swelling, and tension in the contiguous parts. A grating noise when the part is handled, distortion, and a certain degree of loss of power in the injured part, accompany almost every fracture, except when it runs longitudinally, and the divided parts are not completely separated from each other. When there is only a single bone in a limb, a fracture is easily detected; but where only one of two bones of a limb has suffered, it is often difficult to judge with certainty, especially if the contiguous soft parts be tense and painful before the practitioner is called. In that case, the opinion must be regulated, not only by the attendant symptoms, but, 1st, By the age and habit of the patient; for bones are more easily fractured in old than in young persons. Different diseases, too, induce brittleness of the bones, as the lues venerea and sea-scurvy. 2d, By the situation of the part; for bones are more apt to be fractured in the solid parts of their bodies than towards their extremities, where they are more soft and pliant. 3d, By the posture of the limb; for a weight may fracture a bone lying on an unequal surface, which it would have sustained without injury if equally supported. Fractures are sometimes attended with a great degree of echymosis, occasioned by the ends of the fractured bones wounding some of the contiguous blood-vessels.

In giving a prognosis of fracture, various circumstances are to be attended to. It is evident that small fractured bones are more easily healed than large ones, and that the fracture of the middle of a bone is not near so dangerous as near the extremity. A cure is effected much more readily in youth than in old age, and in good constitutions than in bad. We ought also to attend to the concomitant symptoms, and the injury which the neighbouring parts may have sustained. The more moderate the symptoms, the more favourable our prognosis may be.

The treatment of fractures consist of three particulars; replacement, retention, and obviating bad symptoms.

1. When bones are fractured directly across the parts, they are often very little moved from their natural situation; but when the fracture is oblique, they are apt to pass over each other, and to produce much uneasiness and deformity; the contiguous muscles are severely injured, and the pain is aggravated by the slightest motion. The surgeon should put the limb into the best posture for relaxing all the muscles connected with it, according to the practice first introduced by Mr Pott. If it be properly attended to, the ends of the bones will in general be easily replaced. When any difficulty occurs, a small degree of extension may be made, taking care to keep the muscles as relaxed as possible. Much attention should be paid to replacing the bones properly, otherwise the limb will remain for ever after distorted.

2. After the bones are replaced, the limb should be laid in the easiest posture, and the bones afterwards retained in their situation by proper compresses and bandages, not applied too tightly, till the cure be completed. The time necessary for this purpose depends on the size of the bone, the age and habit of the patient, the steadiness with which the limb has been retained in its place, and the violence of the

³⁸⁵ *Fractures in genera.* the attending symptoms. In middle-aged persons, and under favourable circumstances, a fracture of the thigh bone, or of the bones of the leg, may be cured in two months; of the arm bone, or bones of the fore arm, in six weeks; of the ribs, clavicles, and bones of the hand, in three weeks. In infancy the cure will take a shorter, and in old age a longer, time than this.

3. In simple fractures the inflammatory symptoms generally subside in a few days. When they become worse, which is sometimes the case, astringent applications should be employed. If these fail, blood ought to be drawn from the parts affected. This is of so much advantage, that it ought never to be omitted where the surrounding soft parts are much injured. Friction with emollient oils, warm bathing, the use of Bath and other similar waters, are also of much service. The limb sometimes puts on a clumsy appearance from an overgrowth of callus. When this tendency appears, ardent spirits and other astringents are considered as useful; sometimes pressure on the part by a thin plate of lead fixed by a bandage may be advantageous. Many instances occur, however, where no remedies prove successful: The patient ought therefore to be acquainted beforehand with the probable event, to prevent unpleasant reflections afterwards.

Sometimes the ends of the bone remain loose long after they might have been reunited. This may be owing to some constitutional disease, to the bones not being kept steadily in contact, to some of the soft parts getting in between them, or to the bone being broken in different places, and the intermediate fractures being too small to adhere. Pregnancy has also been mentioned as a cause. By removing these obstructions, a perfect union may in recent cases be accomplished. But where the case is of long standing, callus of the bones becomes so hard and smooth as to move with the ease of a joint, so that no advantage can be derived from laying them together. In that case, an incision should be made through the soft parts, and a small portion of the ends of the bone removed with a saw. If this be properly performed, nature will supply the deficiency. When small pieces of bone remain long loose, they should be extracted by making an opening. The intervention of muscles or other soft parts is known by the very severe pain and tension, and by particular motions of the limb causing great pain and twitching of the muscles which move it. The limb should be put into all the variety of situation; and if this does not succeed, an opening must be made, and the soft parts removed. Sometimes in fractures blood-vessels are ruptured by the sharp spiculæ of the bone: this happens most commonly in compound fractures. When the effusion of blood is great, the part swells so much that it is necessary to lay it open, and to secure the divided vessels by a ligature. When the swelling is not great, the absorption of the blood is trusted to nature. When the blood remains long in contact with the fractured bone, it sometimes prevents the formation of callus; the periosteum separates from a considerable portion of the bone, and a thin fetid sanies is discharged at the wound. When this happens, no cure can be expected till the parts of the bone deprived of periosteum have exfoliated, or have been separated by a saw.

SECT. II. *Fractures of the Bones of the Face.*

³⁸⁵ *Fracture of the nose.* FRACTURES of the nose may impede respiration, affect the speech and sense of smelling, give rise to polypi and tedious ulcers, and may besides be dangerous from their vicinity to the brain. When any part of the bones of the nose has been raised above the rest, it is to be pressed into its place with the fingers; if it has been pushed into the nostril, it is to be raised with the end of a spatula or other si-

ilar instrument. If any portion be almost entirely separated from the rest, it should be removed; but if it adheres with considerable firmness, it is to be replaced. If the bones, after being replaced, do not remain in their proper situation, they are to be retained either by tubes introduced into the nostrils, or by a double-headed roller, with proper compresses as the case may require. Inflammation should be prevented by the proper remedies.

Much care is necessary in replacing the fractured bones of the face, and in dressing them, in order to prevent deformity. The dressings may be retained by adhesive plasters. Inflammation, by which the eyes, nose, or antrum maxillare is apt to be injured, should be prevented. When matter collects in the antrum, it is to be removed by the methods formerly described.

³⁸⁶ For replacing fractures of the lower jaw, the patient should be seated in a proper light, with his head firmly secured. The surgeon should press with one hand on the inside of the bone, while with the other he guards against inequalities on the outside. If a tooth come in the way, it should be extracted; when any of the others are forced out of their sockets, they should be replaced, and tied to the neighbouring teeth till they become firm. The fractured parts being kept firm by an assistant, a thick compress of linen or cotton should be laid over the chin, and made to extend from ear to ear over it; a four-headed roller should be applied firm enough to keep the fractured parts in contact. The patient should be kept quiet during the cure, and fed upon spoon-meat. The dressings should be removed as seldom as possible. When the fracture is accompanied with an external wound, the parts should be supported by an assistant during the dressing of it.

SECT. III. *Fractures of the Clavicles, Ribs, Sternum, and Spine.*

³⁸⁷ A FRACTURE of the clavicle is easily discovered by the grating noise in the fractured bone upon moving the arm freely, by the ends of the bone yielding to pressure, and by the motion of the humerus being impeded. All that can be done is to raise the arm, and support it at a proper height, either by a sling, or, which is better, by the leather case recommended in case of luxation of this bone. By this the fractured parts will be brought together, so far at least as to prevent deformity, and render the bone sufficiently strong.

³⁸⁸ Fractures of the ribs are discovered by pressures with the fingers. The symptoms are commonly moderate, and the patient soon gets well. In some cases, however, the pain is severe, the breathing becomes difficult, attended with cough, and perhaps with spitting of blood, and the pulse is quick, full, and sometimes oppressed. These symptoms arise from the ribs being beat in on the lungs.

In the treatment, it is proper in every case to discharge some blood. If one end of the rib rise, it ought to be repressed by moderate pressure; and to prevent its rising again, a broad leather belt should be applied pretty tight, and continued for some weeks. When a portion of the rib is forced inwards, an opening should be made over it with a scalpel, and then it should be elevated with the fingers or a forceps. When distressing symptoms proceed from air or blood collected in the cavity of the chest, these fluids ought to be discharged by an operation.

³⁸⁹ The symptoms of a fractured sternum are nearly the same with those of the ribs. It requires great attention from the vicinity of the heart and large blood-vessels. The patient ought to lose a quantity of blood, and be kept on an antiphlogistic regimen. If the pain, cough, and oppressed breathing, do not yield to these remedies, an incision should be made

Fracture of the Bones, &c. made on the injured part, and the depressed piece raised with a levator. Should this be insufficient, it may be affected by means of the trepan: this indeed requires the greatest caution, but it may certainly be attended with advantage when the patient's life is in danger.

390 Of the vertebrae. Fractures of the vertebrae generally end fatally. We judge of the existence of fracture there by examining the parts, by the severity of the pain, and by palsy occurring in the parts situated below the injured part.

When any parts of the vertebrae near the integuments are loose, they may be replaced with the fingers, and retained by proper bandages. When this is impossible, some of the latest authors think it advisable to make an incision, and raise any portions of the bone which may be depressed.

SECT. IV. *Fracture of the Bones of the Superior Extremities.*

391 Fracture of the scapula. THE scapula is seldom fractured; when it is, the fracture is easily discovered by the pain, the immobility of the arm, and by the touch. The parts may be replaced with greater ease if the muscles connected with them be relaxed. They are retained with difficulty. A long roller should be employed for this purpose, with which the head and shoulders are also to be supported. The arm should also be suspended to relax the muscles as much as possible, and inflammation particularly guarded against by local bleedings.

392 Of the os humeri; Fractures of the humerus are easily discovered by the pain, the immobility of the arm, and a grating noise on handling the parts. In reducing the fracture, the muscles should be completely relaxed by bending the arm and raising it to a horizontal posture. Extension, if necessary, may be made by one assistant grasping the arm between the fracture and the shoulder, and another between the fracture and the elbow. After the reduction, one splint covered with flannel should be laid along the whole outside, and another along the whole inside of the arm; and then a flannel roller applied sufficiently tight to support the parts without interrupting the circulation. The arm may either be supported in a sling or Mr Park's leather case, (fig. 104). The bandages should not be removed for several days, unless some urgent symptoms render it necessary. In about a week, however, the arm should be examined to see whether the bones have been properly set.

393 Of the bones of the fore-arm; When both of the bones of the fore-arm are broken, the fracture is easily discovered; but when only one bone is fractured, especially if it be the radius, the firmness of the other renders the discovery more difficult; the grating noise, however, on moving the bone in different directions, will generally be a sufficient symptom that a fracture has taken place. When the fracture happens near the wrist, particular attention is necessary in order to prevent a stiff joint. In order to replace the parts, the muscles are to be relaxed by bending the joints of the elbow and wrist, and the limb extended a little above and below the fracture. After reduction, a splint reaching from the elbow to the ends of the fingers is to be applied along the radius, and another along the ulna; and both are to be secured with a roller or twelve-tailed bandage. When the splints are applied, the palms should be turned towards the breast as the most convenient posture. The arm should be hung in a sling. A partial dislocation of the bones of the wrist sometimes attends a fracture of the radius, by which a stiff joint, under the best practice, is apt to ensue, or permanent painful swellings of the fore-arm. In such cases, the patient ought to be warned of the danger, that no blame may be afterwards incurred.

394 Of the olecranon; When the olecranon is fractured, the arm must be kept in an extended state during the cure, by applying a splint opposite to the joint of the elbow, reaching from the middle

of the humerus to the points of the fingers. The arm should be hung by the patient's side, to which it should be fixed by means of straps. To prevent the consequences of a stiff joint, the dressings should be removed about the eighth or tenth day, the fore-arm for some time slowly moved backwards and forwards, and the joint rubbed with an emollient oil. By a repetition of this at proper intervals, a stiff joint may be prevented.

Anchylolosis, or stiffness of the joint, commonly succeeds fractures of the bones of the wrist, owing to the great inflammation which ensues, and to their not readily reuniting from their smallness. To prevent this as much as possible, after replacing the bones, the injured parts should be leech-ed freely, and in proportion to the violence of the symptoms. Splints should be applied exactly as in fractures of the fore-arm, and the arm supported by a sling.

396 Of the bones of the fingers. In fractures of the metacarpal bones, a firm splint should be applied over the whole palm and inside of the arm, from the points of the fingers to the elbow, in order to prevent the action of the flexors of the fingers. The best splint for a fractured finger is a piece of firm pasteboard properly fitted and softened in water till it can be readily moulded into the form of the part. This should be applied along the whole length of the finger, and secured with a narrow roller. At the same time, a large roller should be applied over the inside of the hand to prevent the parts from being moved. To prevent stiffness, the dressings should be removed about the end of the second week, and the joint cautiously bent; and this should be repeated daily till the cure be completed.

SECT. V. *Fractures of the Bones of the inferior Extremities.*

397 Fracture of the thigh-bone. FRACTURES of the body of the thigh-bone are readily discovered by the grating noise when the ends of the bones are forcibly rubbed together, by the shortness of the limb if the fracture be oblique, and by the limb being unable to sustain the body. But fractures of the neck of the bone are often not easily distinguished from dislocation of the joint. In general they may be distinguished by the circumstances mentioned in treating of luxations of this bone. In forming a prognosis, we ought to consider that no fractures are more apt to disappoint our expectations than those of the thigh, especially when the neck of the bone is broken, owing to the difficulty of discovering the place of the fracture, and of retaining the bones even after they have been replaced. In order to reduce fractures of the thigh, the muscles are to be relaxed by moderately bending the joints of the thigh and knee: when this is done, unless there be much pain and tension, the bones are easily replaced by one assistant holding the upper part of the thigh, while another supports and gently pulls down its lower extremity, while the surgeon is employed in adjusting the fractured pieces. It is more difficult to reduce fractures of the neck of the bone, on account of the great strength and various directions of the surrounding muscles. In general, however, we shall succeed by moderate extension, if we take care previously to relax all the muscles as much as possible: if we do not succeed, we must have recourse to machinery.

The greatest difficulty is to retain the bones in their situation after they are replaced. The limb must be firmly secured by splints made of thin slips of wood glued to leather (fig. 105. a and b), or of thick pasteboard. One splint, broad enough to cover half of the thigh, should reach from the top of the hip joint to a little below the knee, and another, covering about a third part of the thigh, from the groin to a little below the knee. The splints should be lined with flannel. They are to be secured by a twelve-tailed bandage, and over all a thin pillow should be put nearly as long as the

Fracture of
the Bones,
&c.

the thigh. The splints and bandages may be put on in the following manner: The patient being placed on a firm hair mattress, with his knee moderately bent, the long splint bandage and pillow are to be applied to the outside of the thigh, and the patient should be turned somewhat towards the affected side, with the knee and leg raised a little higher than the body: the short splint should then be applied along the inside of the thigh, and the bandage already placed without the other splint, applied so tight as to make an equal moderate pressure over the whole: (See fig. 106.) To make the part still more secure, it is proper to insert a long firm splint of timber under the middle of the pillow, and to fix it by two broad straps to the upper part of the limb. To prevent the limb from being affected by involuntary startings, the pillow should be fixed to the bed by straps: to keep off the weight of the bed-clothes, a frame with hoops should be placed over the thigh. The parts should be examined after some time to see that the bones be not displaced. When there is pain, swelling, and inflammation, leeches and other remedies should be applied. To render the situation of the patient as easy as possible during the cure, he may be allowed after the second week to turn a little more towards his back, and at the same time to extend the joint of the knee in a small degree: after this time a little flexion and extension of the limb may be daily repeated to preserve the use of the joint.

The method here described generally succeeds. Sometimes, however, notwithstanding all our care, the ends of the bone slip over each other. To prevent the deformity which this occasions, it has been attempted to make extension and counter-extension by machines: but the pain and irritation have always been so great that little advantage has yet been derived from such means. The invention (fig. 107.) of the late Mr Gooch of Norwich, improved by the late Dr Aitken of Edinburgh, has been recommended as one of the best machines for oblique fractures of the thigh. After endeavouring to remove the pain, swelling, and inflammation, which are sometimes so great as to preclude the application of the simplest bandage, this machine may be tried. But if it be found impracticable to use it, the cure must be conducted in the usual way with the chance of the fractured pieces overlapping one another, and of course the limb being somewhat shortened.

398
Fracture
of the pa-
tella.

The *patella* is most frequently fractured transversely, sometimes lengthwise, and sometimes into several pieces. Fractures of this bone have been said commonly to end in a stiff joint; but this is perhaps most frequently owing to the limb being kept too long in an extended posture. In the treatment of fractures of this bone, the leg should be extended to relax as much as possible the soft parts connected with the bone. The patient should be placed on a firm mattress, and a splint be placed under the limb long enough to reach from the top of the thigh to the under end of the leg, to which the limb should be fixed by a number of straps to keep it in a state of extension. The fractured bones are then to be brought together, and such a number of leeches applied to the joint as will remove as much blood as the patient can bear; and as long as much pain and tension continue, saturnine and other astringents are to be used for removing them. When this is accomplished, and the parts properly adjusted, a large pledget of Goulard's cerate should be laid over the joint, and a hooped frame employed to keep off the bed-clothes. In a longitudinal fracture the parts are easily kept together by a common uniting bandage or adhesive plaster; but in transverse fractures more force is necessary. Various bandages have been employed for drawing the pieces together in such fractures; one of the best of these is that represented fig. 108. We need not be

anxious, however, about bringing the pieces very close together, as a cure may be made though they remain at a considerable distance. The bandages, unless particular symptoms occur, should not be removed till the end of the second week; after which the joint should be cautiously bent every second day to prevent stiffness.

The leg is commonly fractured near the lower end, this being the weakest part of the bones. In the treatment of a fractured leg the same rules apply which were given for a fractured thigh-bone. The muscles should be relaxed by bending the knee; but little advantage can be derived from bending the foot, for in proportion as the muscles behind are relaxed those before are put on the stretch: the patient may be therefore allowed to keep the foot in the easiest posture. The bones are commonly replaced by the gentle extension of the upper part of the limb by an assistant, while another supports it at the ankle. The bones being replaced, and the limb laid on its outside with the knee bent, two splints (fig. 109.) are to be applied, long enough to reach from the upper part of the knee to the edge of the sole, so as to prevent the motion both of the knee and ankle. The splints are to be retained by a twelve-tailed bandage, as in the case of fractured thigh-bone. See fig. 106.

If the patient be either very restless or troubled with spasmodic affections of the muscles of the leg, an additional splint, shaped to the form of the leg, should be applied along the outside of it, and fixed by a strap at the upper, and another at the under part of the leg. When the patient cannot rest when lying on either side, he may be placed on his back, and the curved state of the knee still preserved by raising the leg a little above the level of the body on a frame made for the purpose. This variety of posture may likewise be used in fractures of the thigh. The patient may from the first be laid in this posture, or he may alternately change from the one to the other. No change of posture, however, should be allowed for the first ten or twelve days. When the fibula only is fractured, it is apt to be considered as a sprain of some of the muscles; but this ought to be particularly attended to, as the mistake may be followed by bad consequences. When both the bones of the leg are broken, the portion next the foot is commonly drawn towards the back part of the leg, so that a prominence is produced by the fractured part of the upper portion of the bone; and this is improperly termed the rising end of the fractured bone. The appearance is entirely produced by the inferior portion falling back. Hence no advantage is derived from pressure being made on the upper end of the bone: the inferior portion should be raised so as to bring the parts into contact, and then by proper bandages they ought to be supported till they are perfectly united.

Fractures of the bones of the foot and toes are treated nearly in the same manner as fractures of the hand and fingers. Besides the splint which may be necessary for the particular part, a large one should be applied over the sole; nor should any motion be allowed for a considerable time either in the foot or ankle, otherwise the bones may be displaced, and a proper cure prevented.

SECT. VI. Of Compound Fractures.

By compound fracture is now generally meant a fracture of a bone communicating with an external wound in the integuments. They are much more dangerous than simple fractures. The generality of authors have considered amputation as indispensable in cases of compound fractures; while a few, particularly Mr Bilguer, surgeon-general to the armies of the late king of Prussia, affirm that it is scarcely ever necessary. Both seem to have carried matters too far. Some of the latest and best surgeons have recommended

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fractures.

Compound Fractures. mended never to amputate immediately in private practice, unless when the bones are so much shattered that they cannot reunite, or the texture of the soft parts completely destroyed; because, even if amputation be at last necessary, the patient will have a greater chance of recovering than if it had been performed immediately after the accident: for the state of weakness to which he is generally reduced render the attendant symptoms less violent. On the other hand, it has been considered as no bad rule in the army or navy, where patients cannot be kept in a proper situation, and where sufficient attention cannot be given, to amputate immediately in cases of compound fractures of the large bones of the extremities. When amputation is not performed immediately, it is not, for several days at least, admissible. It may afterwards be rendered necessary by hemorrhagies, which cannot be stopped but by means more dangerous than amputation itself; by extensive mortification; or by the ends of the fractured bones remaining long disunited, while a great discharge of matter endangers the patient's life.

Treatment of compound fractures. In treating compound fractures, all extraneous bodies should be removed, as also all those small pieces of bone which will probably not unite with the rest. For this purpose the opening, if necessary, should be enlarged with a scalpel. The next step is to replace the bones by relaxing the muscles as in simple fractures. Sometimes part of a bone projects so far through the integuments that it cannot be replaced without either sawing off the end of it, or enlarging the wound. If the fractured bone be long, sharp, and projecting much, it is best to saw it off; for though it were reduced, it would not readily reunite, and it would be apt to excite much pain and inflammation: But if it be broad at the base, and of no great length, it ought certainly to be sawed, even though it cannot be reduced without enlarging the wound. For the most part, it is only the skin which it is necessary to cut; but even the muscles ought to be divided, though as much as possible in the direction of their fibres, when the bone cannot otherwise be replaced. After the reduction, a pledget of some emollient ointment is to be laid over the wound, and the limb placed on a firm splint, and still kept in a relaxed posture. In dressing the wound, the limb ought not to be moved: the many-tailed bandage, therefore, should be used rather than a roller. Various contrivances have been fallen upon to allow the limb to be at rest while the surgeon is dressing it. The fracture box, invented by the late Mr Rae surgeon in Edinburgh, is one of the best. When the leg is laid on this, it may be dressed with tolerable facility without moving it. We are happy to have it in our power to announce to the gentlemen of the medical faculty, that another machine has lately been invented by Mr Samuel James surgeon in Hoddesden, Herts, which, we are told, will effectually relax the muscles, and retain the bones in their natural situation, without pain to the patient or the least inconvenience to the operator. See fig. 110.

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cccxcii.

It is of the greatest importance to prevent inflammation, which is apt either to produce mortification, or to give rise to extensive abscesses. The dressings should be removed once or twice daily according to the quantity of matter. The common application of warm poultices, on account of their inconvenience, may be deferred till they become necessary by the approach of inflammation, which they are to be considered as the surest means of preventing by exciting a discharge of matter. Whenever the inflammation subsides, and a free discharge of pus is produced, the poultices ought to be laid aside, lest they do harm by relaxing the parts too much, and exciting too copious a discharge. The fore ought then to be dressed with mild astringents, and the patient kept on a nourishing diet with tonic medicines. A free passage should be given to the matter by putting the

limb in a favourable posture, and by making a counter opening, if necessary, to the most depending part. But this may be frequently avoided, by covering the fore with soft lint or sponge to absorb the matter. If the discharge become excessive, and cannot be lessened by the means above-mentioned, it will be found to proceed from a portion of loose bone which has not been earlier noticed, by the removal of which it may be stopt. If, instead of producing matter, the inflammation terminate in gangrene, the danger is still greater than under the most extensive abscesses. For the treatment of this, the reader is referred to Chap. III. Sect. 2d.

CHAP. XXXIII. Of Distortions.

Distortions. DISTORTIONS of the bones may arise from external injuries, from diseased constitutions, from a morbid state of the bones, or a contracted state of the muscles, or both; but the affection is most frequently owing to a weakly, delicate constitution, as in rickety or scrophulous cases.

In the treatment of distortions of the spine, particular attention ought to be paid to the cause of the disorder. If it appear to arise from the patient continuing too long in any particular posture, every habit of this kind should be guarded against on the first appearance of the disease. If the patient has turned too much to one side, the reverse of this should be advised. He ought to sleep upon a firm hair mattress, that his body may lie upon an equal surface. He should use an invigorating diet, the cold bath, bark, and other tonics. By a strict attention to the use of these remedies the disease has sometimes been retarded in its progress. Various machines have been invented for removing distortions of the spine by pressure; but considerable caution is here required, otherwise much injury may arise from it. Some advantage, however, in certain cases, has been derived from the use of the common collar (fig. 111.); or the stays and machinery adapted to them (fig. 112.), invented in France, and afterwards brought into use in this country by Mr Jones of London, are found to be still better suited to this purpose.

The same causes which produce distortions of the spine may likewise produce distortions of the limbs. Sometimes the distortion takes place with the original formation of the bones, at other times it occurs in infancy, and now and then at a more advanced period of life. In early infancy the bones are so pliable as to be readily affected by the postures of the body. When a child is too soon allowed to attempt to walk, its legs are apt to become crooked from their inability to support the weight of the body. Certain diseases likewise, especially rickets, soften the bones so much, that they yield to the posture of the body, and to the common action of their muscles.

When the distortion of a limb is owing to a curvature in a bone, if the case be recent, and especially if it occur in childhood, it may frequently be removed, without much difficulty, by making a gradual but constant pressure, by the use of machinery, on the convex side of the limb, till it recover its natural appearance. When the deformity occurs in the leg, a method has been used, in several instances, which is to fix a firm splint of iron, lined with leather, in the shoe, on the concave side of the leg, the other end of the splint to rest against the under end of the thigh; when, if a broad strap or two be applied round the leg and splint, an easy gradual pressure may be made, and considerable advantage derived from it. See fig. 113.

Along with the curvature above mentioned, it commonly happens that the feet and ankles are affected. When the bones of the leg are bent outward, the fore part of the foot is turned inward, and the inner edge upwards; and the reverse, if the leg be bent inward. In these cases the affec-

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tion.

tions of the feet are generally owing to the curvature of the bones of the leg. By removing the curvature of these, the foot will commonly regain its natural situation, and the splint above mentioned will for the most part be sufficient for the purpose. But in cases where the sole of the foot is turned much out of its natural direction, it may be necessary to fix the splint and shoe to a frame (fig. 114.), which will render the cure still more effectual.

Besides the instrument already mentioned, some have used a kind of boot, cut lengthwise, made of hardened leather or of metal, &c. which may in some cases sufficiently answer the purpose.

In cases of club-foot, where the distortion is in the middle of the foot, a pair of shoes, such as are represented in fig. 115. have been found useful. After the feet are fixed in the shoes, the fore part of the feet may be separated by means of a screw in two plates, which are fixed to the sole.

CHAP. XXXIV. Of Amputation.

SECT. I. Of Amputation in general.

IN amputation, which in surgery signifies cutting off a limb, the great end to be aimed at is, the procuring of a handsome stump, in which the bone may not protrude, but be well covered with flesh; so that no excoriation or rawness may be apt to take place. As long ago as the year 1679, it was proposed by Jacob Young, an English surgeon, in a treatise intitled *Currus Triumphalis ex Terebinthino*, to preserve a flap of flesh and skin, which was to be folded over the bone, and which, uniting to the parts of the wound after amputation, would effectually cover the bone, and prevent the inconveniences above mentioned. No traces of the success of this method, however, can be found till the year 1696; when a Latin dissertation was published upon it by P. Adrians Verduin, an eminent surgeon in Amsterdam. The most sanguine expectations were formed of its success; and it was even thought that the flap would prevent the necessity of tying up the blood-vessels. However, it does not appear that the method as at that time practised either did or could succeed; and accordingly it was entirely laid aside; but it has been lately revived with considerable improvements.

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Causes ren-
dering am-
putation
necessary.

Amputation may be rendered necessary when a member is so much diseased as to be useless, or when it puts life in danger.

The causes in general rendering this operation necessary are, bad compound fractures; extensive lacerated and contused wounds; part of the limb being carried off by a cannon ball or otherwise, the bones being unequally broken and not properly covered; extensive mortification; white swellings of the joints; large exostoses; ulcers attended with extensive caries; cancer or other incurable ulcers; varicose kinds of tumors; particular distortions of the bones.

Amputation may also be sometimes necessary from violent hemorrhagies of some principal artery during the cure of a fractured limb, or from such a profuse discharge of matter taking place that the strength of the patient is exhausted. Lacerated and contused wounds may require amputation, on account of hemorrhagy ensuing which cannot be stopped. Extensive mortification may take place, and such large quantities of matter be formed, that the patient will be unable to bear up under the discharge.

Where part of the limb is carried off, it is necessary to amputate higher up, so as to cut the bone, as well as the soft parts, in such a manner as may admit of a much speedier and safer cure. When mortification occurs, every thing ought to be done for the support of the patient till the

disease be stopped; the first sign of which is, the appearance of an inflamed circle between the diseased and sound parts. As soon as the diseased begin to separate from the sound parts, amputation of the limb ought to be performed, and no time ought now to be lost, lest the patient suffer from the absorption of putrescent matter.

No part of surgery is brought to greater perfection than the manner of performing amputation. Before the invention of the tourniquet, and the method of securing the vessels by ligature, the operation was seldom undertaken; and a great proportion of those upon whom it was performed died soon after. In the present improved method, one death does not happen in twenty, or even thirty cases. In performing the operation, particular attention is to be paid to the spot where the incision is to be made; the quantity of skin and cellular substance necessary to be saved, so as to cover the muscles and bone completely, without being stretched; cutting the muscles in such a manner that they may unite with each other and entirely cover the end of the bone; the prevention of hemorrhagies during the operation; the tying of the arteries alone, without including the nerves or any of the contiguous parts; securing the integuments so as to prevent them from retracting after the operation; and a proper subsequent treatment of the case.

The following are the general steps of the operation: Method of performing amputation. The patient being properly placed, with assistants to attend, and the apparatus in proper order, the flow of the blood to the limb is to be stopped by the tourniquet (fig. 16.). The first incision is to be made through the skin and cellular substance by one, or rather by two, strokes of the amputating knife represented in fig. 116. These are next to be separated from the muscles, as far as may appear sufficient for covering the stump. The separated skin or flap should be strongly drawn up, or what perhaps answers better, turned up all round the limb, leaving this part of the muscles quite bare. The flap is to be kept in this situation by an assistant, while the operator makes the next incision at the edge of the reflected skin, and cuts till he comes to the bone. This incision should be begun on the lower side of the limb, that the blood may not prevent the eye from readily following the edge of the knife during the whole cut. The muscles are now to be separated from the bone as high as may enable them afterwards completely to cover it. The soft parts in general are then to be drawn up by retractors, which may be either of leather, as in fig. 117. or metal, as in fig. 118. *a* and *b*. The periosteum is to be divided at the place where the saw is to be applied; but no part of the bone is to be denuded of this membrane, which is afterwards to cover the stump, otherwise troublesome exfoliations may ensue. At this place the saw (fig. 119.) is to be applied, and the bone divided with long steady strokes. In this part of the operation a good deal depends upon the steadiness of the assistant who holds the limb; for if it be held too high, the motion of the saw will be impeded; while the bone may be splintered if it be not sufficiently raised. Any points or splinters which may be left should be immediately removed with the pincers (fig. 120.). The retractors are now to be laid aside, and the principal arteries separated from the nerves, and secured by the tenaculum (fig. 17.), or forceps (fig. 120. *a*), and ligatures.

The tourniquet should next be a little slackened, to allow the different branches to be discovered: The clotted blood is to be cleared away with a warm sponge. The patient should get some warm cordial drink, and all the arterial branches which can be discovered ought to be taken up. The ends of the ligatures are then to be cut of such a length as to allow them to hang without the lips of the wound. The muscles and skin are now to be drawn down, and brought into

Amputa-
ting the
Arm and
Fore arm.

into close contact, that the stump may be completely covered. The parts are next to be secured by proper bandaging; and if the operation has been properly performed, the cure will commonly be made by the first intention, and may be completed in the course of three or four weeks, and sometimes in a shorter period. This however must depend much upon the constitution of the patient, as well as the manner of performing the operation.

SECT. II. *Of Amputating the Arm and Fore-arm.*

AMPUTATION of the arm is performed according to the rules already laid down. No more of it should be removed than is diseased; for the longer the stump is, the more useful it proves. The tourniquet is to be applied a little above the part where the operation is to be performed: As much of the integuments should be saved as may be perfectly sufficient for covering the fore. In taking up the artery, after the bone has been divided, the operator ought to be attentive not to include the radial nerve, which may be readily discovered and separated, as it lies close upon the fore part of the artery. The fore-arm is to be amputated nearly in the same manner as the leg; only that the stump may be covered by amputating with the double incision, without the assistance of a flap, which it is necessary to form in the leg.

SECT. III. *Of Amputating the Thigh.*

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Method of
performing
the ampu-
tation.

IN performing this operation, the patient ought to be placed upon a table of ordinary height, with the diseased limb supported and secured by an assistant seated before him, while other assistants take care of the other leg and the arms. The course of the blood is to be stopped by applying the tourniquet over the trunk of the femoral artery, near the upper part of the thigh. No more of the thigh ought to be removed than is rendered necessary by the disease, as the more of it is left, the more useful it will be to the patient. An assistant should grasp the limb with both hands a little above the place where the skin is to be divided, and draw it up as far as possible; while the operator, standing on the outside of the limb, makes a circular incision down to the muscles by one or two strokes of the knife. As much of the integuments is then to be dissected with a scalpel from the muscles as may cover the stump completely; and this part of the skin may either be turned back, or drawn tightly up by an assistant. The muscles may then be divided quite across to the bone by the edge of the skin, in the common way, or cut obliquely upwards, according to the method of Allanson, so as to lay the bone bare two or three fingers-breadth higher than is done in the common way. The muscles are next to be separated from the bone with a scalpel a little way, that a sufficient quantity may be left for covering the end of it. The rest of the operation is to be performed exactly according to the general rules laid down in the first section of this chapter. The muscles and integuments are to be drawn over the end of the bone, and applied closely together, that the skin may completely cover the stump, and retained in this situation by an assistant, till a flannel or cotton roller, according to the season of the year, which has been previously fixed round the body, be applied in such a manner as to support and fix them. For which purpose it should be passed two or three times, in a circular direction, round the top of the thigh, and should afterwards, with spiral turns, be brought down near to the end of the stump and fastened with pins; and it should not be tighter than may be sufficient to assist the plasters in preventing retraction.

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Of dressing
the stump.

The ends of the divided muscles are now to be laid exactly over the bone; and the edges of the skin are to be

brought into contact, either so as to form a straight longitudinal line, according to the method of Mr B. Bell, &c. or they are to be placed horizontally, "that the wound may appear only in a line with the angles at each side," as advised by Allanson. The ligatures may either hang over the edges of the wound, or be brought to the angles. After the edges of the skin are in this manner exactly applied to each other, either a few slips of adhesive plaster are to be laid across the face of the stump, or two large pieces of adhesive plaster, with several pieces of tape fixed to them, are to be applied to the surface of the skin. The tapes are then to be tied with a running knot immediately over the wound; by which the parts will be kept so closely together as to prevent any collection of matter from being formed. The whole surface of the stump should next be covered with a large pledget spread with an emollient ointment, over which a compress of fine tow is to be put, and retained in its place by a broad cross strap of old linen, passing some way up the thigh, so as to be secured by the roller, which is now to be passed two or three times round the stump; and the pressure formed by the cross strap may afterwards be increased or diminished at pleasure, by drawing it with more or less tightness, and fixing it with pins to the roller. While the stump is dressing, the tourniquet is removed, but replaced again loosely to enable the attendants to check any hemorrhagy which may afterwards ensue.

The patient is now to be laid to rest, and the limb is to be placed upon a little tow covered with linen, or upon a thin soft pillow; and to prevent the patient from involuntarily moving the limb, and to guard against spasmodic startings, which frequently happen after this operation, it may be fixed to the bed by two straps. A basket or hooped frame ought to be placed over the stump to protect it from the bed-clothes. The patient should immediately get an anodyne draught, which will generally procure ease through the rest of the day. For this purpose, no more light should be let into the room than is merely necessary for allowing the attendants to pay attention to the stump. As hemorrhagies sometimes appear several hours after the operation, the person who takes the charge of the patient should watch this circumstance with the greatest attention. If there be only a slight oozing of blood, there is no occasion for being alarmed; but whenever it appears to proceed from a large artery, it must be secured. The spasmodic affections which frequently occur after amputation are seldom troublesome, unless some nerve has been included in securing the arteries; but when they do appear, laying the limb in the easiest posture, and giving opiates, are the principal means of procuring relief.

To prevent inflammation as much as possible, the patient is to be kept upon a strict antiphlogistic regimen, and his bowels kept open by laxative clysters, till the inflammatory stage is over, which will generally be in a few days. If, notwithstanding this treatment, the stump swells, and the patient complain of pain and tightness, we ought to endeavour to discover from what cause the uneasiness originates. If it be owing to the straps being too tightly fixed, they must be slackened. If the stump be found much swelled, a saturnine solution should be applied by means of several folds of linen; and if the patient be young and plethoric, he ought to lose a few ounces of blood from the arm; but if he is weak and emaciated, a different mode of treatment must be followed.

At the end of the third, or fourth day at farthest, the stump should be examined; and if it appear somewhat open and flaccid, the parts must be brought closer together and secured more firmly. After this time the dressings should be renewed every day, or every second day. In about a week

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Treatment
of the pa-
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tion.

Amputa-
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Leg.

week after the operation the ligatures may generally be removed with ease; but if they do not separate readily, they may be gently pulled at every dressing, when they will, in a short time, be brought away, and the wound will be soon healed by the first intention. The roller should be cleaned and renewed as often as it is found sullied; nor should it be laid entirely aside till the end of the third or fourth week after the operation. When the roller is removed, we may depend upon the straps or tapes for keeping the parts together till the cure be quite accomplished. When the inflammatory symptoms are entirely gone, no medicines ought to be given which would debilitate the patient, nor is any thing more necessary, than to keep the bowels gently open till a complete cure be made.

SECT. IV. *Of Amputating the Leg.*

THE leg may be amputated for a disease in the foot at two different parts; the one a hand-breadth under the knee, the other a little above the ankle. The former makes a sufficient support for the body to rest upon an artificial leg; but the latter does that equally well, and likewise preserves the motions of the knee.

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Amputa-
tion of the
leg near the
knee.

In performing the operation a little way under the knee, the patient is to be placed and secured in the same manner as in operating upon the thigh. The tourniquet is to be placed a little above the knee, with the cushion upon the artery in the ham. The surgeon places himself upon the inside of the leg, and makes a circular incision through the integuments down to the muscles. The place where the incision should be made must depend upon the length of the limb; but in general it may be between six and seven inches under the top of the tibia in an adult, or far enough down upon the limb to save as much integuments as will cover the stump. After the integuments are cut through in the manner already directed, as much of the muscles are to be divided by the knife as can be done by a circular incision; and the interosseous parts are to be divided by a scalpel or catline, (fig. 121.). The retractors are then to be applied, and the bone sawed off immediately below the insertion of the tendons of the flexor muscles. In sawing, the operator ought to begin upon both bones at the same time, that he may finish upon the tibia, lest splinters should be formed. The vessels are next to be secured; the soft parts drawn over the bones; the adhesive plasters and other bandages applied in the same manner as directed for amputating the thigh, only that here the roller need not be applied so high as in the former operation. Two or three turns above the knee, however, are necessary to prevent the dressings from slipping down.

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At the an-
kle.

In amputating upon the ankle, the operator should fix upon that spot which will leave the stump of such a length as may be most convenient for being fitted with an artificial machine resembling the other leg. Nine inches from the joint of the knee, in a leg of ordinary length, was found by Mr Wilson, a late ingenious artificial limb-maker in Edinburgh, to be the best part suited to this purpose, on account of the equal pressure it makes upon the surface of the leg, without making any upon the end of the tender stump. The operation is performed in the same manner as that a little below the knee.

SECT. V. *Of Amputating at the Joints of the Extremities.*

THE circumstances most to be attended to in performing amputation at the joints are, first to stop the circulation by the tourniquet; or, where that is impracticable, to take up the trunk of the artery by a ligature; to make a circular incision in such a place as may, after the operation is over, be sufficient to cover the wound: Then a longitudinal in-

cision is to be made upon the opposite sides of the limb, extending from the joint to the circular cut, and as deep as the bone, by which two flaps will be formed to cover that part of the joint which remains after the operation is finished. The ligaments of the joint are next to be divided, and the affected limb or part of the limb removed.

After this part of the operation, it was formerly a frequent practice to scrape off the remaining cartilage, to unite the parts more firmly together. But this is now found to be unnecessary; for when the flesh is applied properly to the bone, if it do not grow to it, the union at least is so close that it afterwards gives no inconvenience to the patient.

Any branches of arteries which may have been cut during the operation are now to be secured; clotted blood is to be removed; and the muscles and skin are to be brought into close contact with the ends of the ligatures hanging out of the wound. The parts are to be retained by adhesive plasters, or twisted suture, or both; and proper bandages applied in such a way that a cure may be made by the first intention.

Amputating the arm at the shoulder-joint has always been considered as a dangerous as well as a difficult operation. It should never be attempted, when the same purpose can be accomplished by operating lower down. But cases occasionally occur, where the life of the patient cannot, in any other manner, be saved.

Amputation may become necessary here in consequence of abscesses of the joint; caries of the humerus reaching to the joint; compound fractures, especially those from gunshot wounds, extending to the head of the bone; and of mortification.

In performing the operation, the patient should be laid upon a table of convenient height, covered with a mattress. He is then to be brought as near to the edge of it as possible, and secured by assistants. The circulation of the blood in the arm is next to be stopped, by an assistant pressing strongly with a firm compress over the subclavian artery where it passes over the first rib; or an incision may be made along the course of the artery, which may be secured after separating from it the contiguous nerves. When the artery is compressed, it will readily be known whether the compression proves effectual, by observing when the pulse at the wrist is entirely stopped. As soon as this is the case, a circular incision is to be made through the integuments at the insertion of the deltoid muscle into the humerus. An assistant then draws the skin a little back, and at the edge of the retracted skin the muscles are to be cut in a circular direction to the bone.

If the artery has not been taken up at the beginning of the operation, it is now to be secured, as well as any branches which come in the way.

The amputation-knife is now to be laid aside, and the rest of the operation finished with a strong scalpel. A perpendicular incision is next to be made at a little distance from the outside of the artery, beginning at the acromion, and terminating in the circular incision, cutting as deep as the surface of the bone. A similar incision is to be made upon the back part of the arm, so that the flaps may be nearly of an equal breadth. The arterial branches are here to be secured; the flaps are to be separated from the bone, guarding against wounding the trunk of the artery; the flaps are to be supported by an assistant; and the capsular ligament of the joint is to be cut from the scapula: and thus the arm will be entirely separated.

After the arm has been separated, any arteries which appear about the joint are to be tied, and all the ligatures brought over the edges of the wound. The parts are to be cleared of clotted blood, and the two flaps drawn over the wound,

Amputa-
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Joints of
the Extre-
mities.

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At the
wrist.

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At the
joints of the
fingers.

wound, and secured by the twisted suture. A pledget of any emollient should then be applied, and a sufficient cushion of lint, with a compress of old linen, put over the whole. A moderate pressure is next to be applied by a flannel roller; by which the parts will be supported, their union facilitated, and matter most likely prevented from being lodged. The treatment is then the same with that after amputation in other parts of the extremities. For two or three days after the operation, it is necessary that an assistant sit with the patient to compress the artery in case a bleeding should ensue.

When it is necessary to amputate the whole hand, the operation may be performed at the wrist, so as to leave as much of the member as possible; and the same rules hold here as in amputating at any of the rest of the joints. The tourniquet is to be applied to the artery in the arm, and the cure is to be completed by the first intention. When any of the carpal bones are affected, the fore will not heal till they either work out by suppuration, or are cut out by the knife. When the middle of any of the metacarpal bones is diseased, while their extremities are sound, the trepan may be applied, and the diseased parts removed, while the remaining sound parts are preserved. But if the whole bodies of one or two of these bones be affected, while the rest remain sound, all the affected bones ought to be removed. In performing the operation, an incision is to be made along the course of the part affected; and if the operator have it in his choice, the incision should be made upon the back part, so as to save the great vessels and nerves situated in the palm. The integuments are then to be dissected, and turned to each side; after which the diseased bones or parts of bones are to be removed, guarding as much as possible against wounding the principal arteries or nerves which lie near them.

The diseased parts are next to be separated; any arteries which happen to be cut are to be secured; and, on account of the free communication which they have with neighbouring branches, they ought to be tied at both cut ends. If after this a bleeding still continue, compress, styptics, and other remedies proper for stopping blood, are immediately to be used. The sides of the wound are to be brought together, and an attempt made to cure them by the first intention.

In amputating the fingers, it was formerly the practice to operate upon the bodies of the bones in the same manner as in the larger extremities; but at present the removal at the joints is more frequently practised.

In performing the operation, it is necessary to save as much skin as may cover the stump, and this ought to be done upon the side next the palm, so as to guard against the effects of friction. The general steps of the operation are the same with those for amputation of the larger joints.

A circular incision is to be made on the finger by a crooked bistoury, about the middle of the phalanx, and it may be carried at once to the bone. Another incision is to be made with a common scalpel at each side of the finger, beginning at the circular one and continuing it to the joint, by which two flaps will be left to cover the stump. The ligaments of the joint are now to be divided, and the bone removed. The blood-vessels are to be secured by ligature, and the flaps exactly applied to each other; but in order to protect the end of the bone completely, a small portion may be cut from the uppermost flap. The flaps are to be retained by adhesive plaster, or by the twisted suture; but if the latter be used, the tendons ought to be avoided. Over the fore an emollient pledget is to be applied, and then a compress and roller. If the disease be so situated,

that instead of amputating at the cavity of the joint, the Amputa-
surgeon shall think proper to operate upon the body of the ting at the
bone, flaps are to be formed as above, and the bone is to be Joints of
divided by means of a small spring saw, fig. 122. the Extre-
mities.

The amputation of the thigh, at the hip joint, has always been considered as one of the most formidable operations in surgery; so much so, that very few cases appear on record of its having ever been put in practice. In the Medical Commentaries of Edinburgh, an instance is recorded where the thigh was amputated at this joint, and where the patient survived the operation 18 days, and then died from a different cause, when all risk of hæmorrhagy was over, and when the sore had even a favourable appearance, which shows at least that the operation has been done with safety. It certainly ought never to be done, however, unless as the last resource, and when the life of the patient is in absolute danger; and then only when as much skin and muscles can be saved as will cover the sore, and when there is also a probability of being able to stop the hæmorrhagy, and prevent it from returning.

When the operation is to be performed, the patient is to be laid upon his back on a table, and properly secured by assistants; one of whom should be ready with a firm cushion to press, if necessary, upon the top of the femoral artery, just after it passes from behind Poupart's ligament to the thigh. A longitudinal incision is now to be made through the skin, beginning immediately under the ligament, and continuing it downwards along the course of the artery for about six or seven inches. The aponeurosis of the thigh is then to be divided by gentle scratches till a furrowed probe can be introduced, when the opening is to be dilated by means of a scalpel, till two or three inches of the artery be laid bare. A strong ligature is now to be put under the artery by the assistance of a curved blunt-pointed needle.

The part where the ligature should be passed is immediately above the origin of the arteria profunda; for if that artery be not affected by the ligature, the patient might suffer by the loss of blood during the rest of the operation. The ligature is now to be secured by a running-knot: Another ligature is to be introduced a little below the former, and likewise secured; the artery is then to be divided between the ligatures. A circular incision is now to be made through the integuments of the thigh, about six inches from its upper end. The retracted skin is then to be pulled at least an inch upwards; and at the edges of it the amputating knife is to be applied, so as to cut the muscles down to the bone. This being done, a cut is to be made upon the posterior part of the thigh, beginning a little higher than the great trochanter, and continuing it down to the circular incision, and as deep as the joint. A similar cut is to be made on the anterior part of the thigh, at a small distance from the artery, and this reaching likewise down to the bone. The two muscular flaps are to be separated from the bone and joint, and held back by an assistant. Every artery which appears is now to be secured. Then the capsular ligament, and next the round one, are to be separated from the acetabulum; by which means the limb will be removed from the body. The acetabulum and neighbouring bone are next to be examined; and if they appear sound, the case will be more favourable; but at any rate, a cure is to be attempted by the first intention. For which purpose, after removing all the clotted blood from the surface of the wound, and bringing the ligatures over the edges of the skin, the muscles are to be placed as nearly as possible in their natural situation; and drawing the flaps together, so as to cover the wound in the most accurate manner, they are to be kept in this situation by adhesive plaster, and

Amputa-
ting at the
Joints of
the Extre-
mities.

416
At the hip
joint.

Removing
the Ends of
Carius
Bones in the
Joints.

by the twisted suture and other dressings, as in amputating at the under part of the thigh. The dressings are to be retained by a broad flannel roller passed three or four times round the body, and spirally over the stump, and secured. The patient is then to be laid in bed on the sound side, and treated as for amputation in other parts of the body; only that greater attention is necessary, as there is no assistance from a tourniquet. Uncommon attention will also be necessary to prevent inflammation, and every symptom of fever which may succeed to the operation.

417
At the
joints of
the foot.

When the foot is so much diseased as to require amputation, the operation might be performed at the point of the ankle; but for the reasons given, when treating of amputation of the leg, it is found better to do it above the ankle. When a considerable part remains sound, it ought to be saved. If any of the tarsal bones are affected, these are to be removed. When the middle or whole body of any of the metatarsal bones are diseased, they are to be removed in the same manner as directed for similar operations in bones of the hand; and if even two of them remain sound, provided they be so placed as to support the toes, they ought to be preserved, as it is known that, by proper treatment, an osseous matter may afterwards fill a considerable part, if not the whole, of the void; or if any cavity remain, it may be so stuffed that the use of the foot may still be enjoyed.

In performing an operation of this kind, the patient should be laid upon a table, and the tourniquet applied in the ham to prevent hemorrhagy. An incision is then to be made along the affected part; and if the seat of the disease admit it, the incision should be made upon the upper side of the foot so as to save the sole. The integuments are to be separated and turned to each side, to allow the affected parts to be completely removed.

The principal vessels and nerves are to be saved as much as possible; but if any particular artery be cut, it is to be secured, and the part treated as after the removal of similar parts of the hand.

418
Of the toes.

The amputation of the toes is exactly similar to that of the fingers.

SECT. V. *Of removing the Ends of Carious Bones in the Joints.*

IN compound fractures, the ends of bones, when they protruded in such a manner that they could not otherwise be returned, have frequently been sawed through; and their place has frequently been supplied by a renewal of bone, so as to preserve the ordinary use of the limb. Many cases have likewise happened, where a large part of the body of the bone has been thrown out by suppuration, and its place supplied; and a few are upon record, where either the whole of a bone, or that end next the joint, has been thrown out, and its place filled up with callus, so that no inconvenience has been felt. From these circumstances, Mr White of Manchester was led to preserve an arm by sawing off the head of a diseased humerus; and Mr Park of Liverpool, to save a limb, by sawing off the ends of the bones, in a case of white swelling of the knee. When therefore it happens that the end of a bone is diseased, while the other parts are sound, the diseased part may be removed, and the sound one saved, so as in a great measure to preserve the free use of the limb.

In performing the operation, the first step should be, to use such means as may enable the operator to have a full management of the circulation of the part affected. Then a longitudinal incision of sufficient length, and perhaps another across it, may be necessary to be made through the soft parts of the joint; and this opening ought to be at a di-

stance from the large blood-vessels, that they may be in no danger of being injured. After the end of the diseased bone is sufficiently laid bare, it is either to be brought out of the joint, or a spatula or some other proper substance is to be introduced between the bone and soft parts, so as to defend the latter in time of sawing the bone. After the diseased part of the bone is removed, the arterial branches are to be secured, and the wound treated like any other wound of equal size.

During the cure the limb ought to be kept in the posture most favourable for the removal of the bone, and afterwards for the preservation of the natural motion of the joint.

In this way a limb may sometimes be saved which would otherwise have been removed. But though the removal of the diseased end of one bone may be readily effected, the removal of all that part of the bones which enters into the composition of a joint must be attended with so much inconvenience, that it can seldom be useful, unless it be where the ends of bones are destroyed by external violence; for then it appears that this operation may be performed with considerable success.

CHAP. XXXV. *Of Diminishing Pain in Surgical Operations.*

THE pain induced by surgical operations may be lessened in two different ways. The first is, by diminishing the natural sensibility of the system; and for this purpose narcotics of different kinds, and particularly opium, have been used; but these are apt to induce disagreeable symptoms, especially sickness and vomiting, which might be attended with bad consequences after some operations. They are therefore seldom employed before an operation. When, however, they are given immediately after it, and repeated as circumstances may require, they often give great relief.

The other method of diminishing pain is, by lessening the sensibility of a particular part of the body. It has long been known, that the sensibility of any part may not only be lessened, but entirely suspended, by compressing the nerves which supply it. From a knowledge of this circumstance, an instrument (fig. 123.) was invented some years ago by Mr James Moore of London, by which the principal nerves of a member might be so compressed as to render the parts below perfectly insensible. A difficulty, however, arises here; for as the nerves must be compressed at least an hour previous to the operation, in order to render the parts quite insensible, and as it is extremely difficult to compress the nerves without at the same time affecting the veins, the latter are therefore in danger of being burst. To prevent this inconvenience, Mr Moore proposes to open a vein; but this might be attended with bad consequences in weakly constitutions. Besides, it is said, that by compressing the nerves in this manner, although less pain may be felt in the time of the operation, it is proportionally greater after the compression is removed. In certain parts of the body, however, where sufficient compression can be made upon the nerves without acting much upon the veins, it would appear that the method may be practised with advantage; though it has not yet been done, excepting in a few instances.

CHAP. XXXVI. *Of Bandages.*

THE proper application of bandages is an object of great importance in surgery; and though dexterity is only to be acquired in this branch by practice, yet a few general rules may be found useful. Bandages are employed for the retention of dressings, for stopping hemorrhagies, for re-

moving

Bandages moving deformities, and for effecting the union of divided parts. They ought to be formed of such materials as are sufficiently firm, while, at the same time, they give no uneasiness to the parts to which they are applied. They may be composed either of linen, cotton, or flannel. Of late years the two last have been preferred by many for their warmth and elasticity, on which account they are certainly most proper, especially in winter; and likewise in cases where the parts are liable to swelling and inflammation, as in wounds, luxations, and fractures. Besides, they more readily absorb any moisture which may be discharged from the sores.

When first applied, they should be clean, sufficiently strong, and as free of seams as possible. They should be so tightly applied as to answer the purpose for which they are intended, without being in danger of impeding the circulation. They should be applied in such a manner that they may be easily loosened, and the parts examined with as much accuracy as possible; and they should be laid aside as soon as the purpose for which they are intended is accomplished; for when longer continued, they frequently impede the growth of the parts upon which they are applied.

419
Bandages
for the
head.

With respect to bandages for particular parts, we shall begin with the head, and then proceed to the trunk and extremities. The *couvre chef* of the French, which is a square napkin folded cornerwise, is most frequently used where a bandage is wanted for the head; but a nightcap, having a band to go round the head, and another to tie under the chin, appears to be more suitable for this purpose. For making compression on any particular part of the head, as for stopping of bleeding vessels, the radiated bandage may be employed.

For keeping the edges of wounds together, as in cases of longitudinal cuts of the head, or of any other parts, the uniting bandage is usually employed, and is always to be preferred to sutures, where it retains the edges of the wound with sufficient exactness. For retaining dressings upon the eyes, several turns of a roller have been used, and it is termed *monoculus* or *binoculus* according to its being applied to one or both eyes; but the *couvre chef*, and the nightcap already mentioned, are less apt to slip, and therefore found more convenient for this purpose.

410
For the
face.

For fractures of the nose, or wounds there, or on any other part of the face, the uniting bandage answers best. And in cases of fracture of the lower jaw, a four-headed roller is most convenient: the hole in the centre of the roller receives the chin, and assists in preventing the bandage from shifting. The two upper heads are to be carried backwards; and being made to pass each other at the occiput, they are afterwards brought once or twice round the head. The two under heads of the roller being reflected over the chin, are then to be turned upwards and fixed on the upper part of the head.

411
For the
neck.

The bandages necessary for the neck are, the machine already mentioned after the operation of bronchotomy, and one used in cases of wry neck. For every other purpose of bandaging a common roller may answer perfectly well.

For fractures of the scapula the application of a long roller may be of service.

412
For the
breast.

For retaining dressings upon the thorax the napkin and scapulary are commonly, and very properly used; and when the napkin is employed merely for retaining dressings, it need not be longer than to pass once round the body; but if it be used for making pressure over a fractured rib, it ought to pass two or three times round. For both purposes its breadth ought to be six or seven inches for an adult.

The same kind of bandages is also used for making pres-

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sure on the abdomen, as in cases of umbilical or ventral hernia; and to keep the bandage properly placed, a scapulary is used for preventing it from slipping down, and one or two straps connected with it behind, are brought between the thighs, and fixed to it before to prevent it from moving up. A bandage of flannel, and different kinds of belts, are contrived for compressing the abdomen in the operation of taping; and trusses of various constructions are used for the retention of the protruded bowels in cases of hernia.

Method of
opening a
dead Body.
423
For the
belly.

Bandages of cotton or flannel are used for supporting the scrotum in the various diseases which may occur there, as well as after the operations performed upon it.

424
For the
scrotum
and penis.

One of the best bandages for the penis is a linen or cotton bag, fixed by a roller round the body.

For retaining dressings about the anus, or between that part and the scrotum, the T bandage is commonly used; and it is made either with one or two tails, according to the situation of the part to which it is to be applied.

415
For the
anus.

In simple fractures, and most of the other diseases of the arm, fore-arm, and hand, the roller is the bandage commonly used; but in compound fractures of these parts, as well as in the different kinds of fractures of the lower extremities, the 12 or 18 tailed bandage is necessary.

426
For frac-
tures.

For longitudinal wounds of the extremities, the uniting bandage is used with the same advantage as has been already mentioned for wounds of a similar nature upon the head.

427
For wounds
of the ex-
tremities.

CHAP. XXXVII. The Method of opening a dead Body.

SURGEONS are often called, in order to investigate the cause and seat of diseases and death, either by the relations of the deceased, or the magistrates to whom a report is to be made; therefore, at the time of performing this operation, minutes should be taken of what is observed. The instruments, and all things necessary, should be disposed in order, as for any other operation; as knives, a razor, a great and small saw, scissors straight and curved, elevators, needles threaded, sponges, tow, saw-dust or bran, basons with water, towels, and receivers for the viscera when they are to be taken out of their cavities. The body is to be laid upon a suitable table, advantageously placed for the light, having a cloth thrown over the parts which decency demands should be concealed, especially in females.

When it is intended only to inspect the abdomen and its contents, a longitudinal incision from the xiphoid cartilage to the os pubis, intersected by a transverse one at the navel, will give a fair opportunity of answering these purposes, when the angles are reversed. Should it be required to examine all the three cavities, and the parts contained in them, we are to begin by opening the head, making an incision quite cross to the bone, from ear to ear; which section is preferable to the crucial, commonly made on this occasion: then the scalp may be easily dissected from the skull, and turned down over the face, and towards the neck, giving room for the saw. The head must be held very steadily by an assistant during the sawing, which should be begun on the middle of the frontal, proceeding to each temporal bone, and so to finish the circle upon the middle of the occipital bone; which may generally be done conveniently enough, by raising the head and inclining it forward after having proceeded as far as this bone; or the body may then be turned prone, should that posture be found more convenient to complete the circle. The cap of the skull is then to be raised with the elevator, occasionally cutting the adhesions of the dura mater; after this the encephalon is to be removed, carefully separating the other attachments of the membrane.

428
Method of
opening
the cra-
nium.

In order to bring the thorax and abdomen, with the parts

A a

contained

Method of
opening a
dead Body.

429
Of opening
the thorax
and abdo-
men.

contained in these cavities, under one view, an incision is to be made on each side of the sternum, in the course of the cartilages of the ribs which are annexed to it; dissecting from thence the muscles with the teguments, the space of two or three inches towards the spine; then cutting through the cartilages, which will be seen, and easily divided with a knife a little curved near the point; then the incisions are to be continued from the sternum through the abdominal cavity, in an oblique direction, to each ilium or inguen; after which the clavicles are to be separated from the sternum, or this bone divided at its superior cartilaginous junction, with a strong knife, dissecting it from the mediastinum, and turning it downwards with the muscles, &c. of the abdomen. This is the most eligible manner of opening these cavities, and gives an opportunity of sewing them up with a better appearance for any person's view afterwards. That kind of sitch called by sempstresses the *herring-bone* or *flat seam* has a very pretty and neat effect upon these occasions.

If it is proposed to take out the thoracic and abdominal viscera together, for further examination, the diaphragm is first to be cut down to the spine on both sides; then, to avoid being incommoded with blood, &c. two very strong ligatures are to be passed round the œsophagus and large blood-vessels, in which the trachea may be included; tying them strait, and then dividing these parts between the ligatures: the same measures are to be taken in respect to the inferior vessels upon the lumbar region, a little above the bifurcation of the aorta, including the vena cava; and also upon the rectum. After having observed these precautions, the viscera, with the diaphragm, are to be removed by a wary dissection, all the way close to the spine; and by gently drawing them at the same time, the separation will be greatly facilitated.

When the thoracic and abdominal viscera are to be taken out separately, in the first case ligatures must be made, as have been described upon the vessels, &c. just above the diaphragm, and in the other just below it, and upon the rectum.

430
When the
body is be-
come pu-
trid, how it
is to be ma-
naged.

Should we be called upon to perform this office when the body is become very putrid, it will be absolutely necessary to have such parts of it well washed with warm vinegar and brandy, and then sprinkled with lavender-water or some such odoriferous antiputrescent liquor, before the examination, in order to correct the stench, and defend us against the noxious quality of the effluvia; a precaution, the neglect of which may be attended with very direful effects.

CHAP. XXXVIII. Of Embalming dead Bodies.

In the early ages of the world, the practice of embalming dead bodies was very common, particularly among the Egyptians; but it has long been disused in almost all countries, except for great personages. See EMBALMING. The following directions are taken from Mr Gooch, to whom they were communicated by a person of great character, and well acquainted with the modern practice of embalming in this kingdom.

After evisceration, as has been directed in opening a dead body, and continuing the incision farther upwards, even into the mouth, and, if practicable, without cutting the skin of the neck, all the cavities are to be well cleansed, and the humidity sucked up with sponges, then washed with *tinct. myrrhe*, and filled with a species compounded of fragrant herbs, aromatic drugs, and gums reduced to powder not very fine, first restoring the heart to its former residence, after having opened its ventricles, cleansed and washed them with the tincture, stuffed them with the spices, and sewed

them up; and then the cavities are to be stitched very close with the glover's or spiral suture. Large and deep incisions are also to be made in all the most fleshy parts, cleaning and washing them with the tincture in the same manner, filling them with the antiseptic spices, and stitching them up. Then the head, trunk, and limbs, are to be perfectly well covered with cerecloth; putting a piece under the chin, to be secured by sewing on the top of the head, after having well adjusted the cap of the skull, sewed the scalp together, and cleaned the mouth, as has been directed for the other parts, and putting in some of the spices. The cerecloth is to be prepared, according to art, with a composition made of wax, rosin, storax, and painter's drying oil. After the application of the cerecloth, with great care and exactness, cut into suitable pieces according to the respective parts, and closing them well everywhere, the face being close shaved, is to be covered with some of the above composition melted, and laid on with a brush of a proper degree of heat, and of a moderate thickness; which may have a faint flesh-colour given it with vermilion; and when it is grown cold and stiff upon this part, it may be lightly covered with hard varnish; or this varnish, applied thick, may here serve the purpose alone. A cap is to be well adapted to the head, falling down upon the neck, and to be sewed under the chin, making a few circular turns about the neck with a roller of a proper breadth. All the rest of the corpse is to be inclosed in a sheet, to be artfully cut, and sewed on very close and smooth, with the finest tape, and the *flat seam* mentioned in the preceding chapter; over which an appropriate dress is to be put, as the relations or friends think fit to direct and appoint, and then laid into the coffin, which should be in readiness: but when it is some great personage, who is to lie in state for public view before the funeral rites are solemnized, the dress must be appropriated to his dignity and character. The brain and other viscera are to be put with some of the spices into a leaden box. Sometimes the heart, prepared as has been directed, to preserve it from putrefaction, is deposited in an urn by itself.

EXPLANATION OF PLATES.

PLATE CCCCLXXXVII. Fig. 1. A lancet and canula for discharging the contents of an abscess by means of a seton. See n° 50.

Fig. 2. A director for discharging the contents of an abscess. See n° 50.

Fig. 3. An abscess lancet.

Fig. 4. A forceps for extracting polypi. See n° 113.

Fig. 5. A slit probe for conducting a ligature to the root of a polypus. See n° 114.

Fig. 6. A ring for assisting in securing a ligature upon the root of a polypus. See n° 114.

Fig. 7. A double canula for fixing a ligature upon the root of a polypus. See n° 114.

Fig. 8. The most approved form of a lancet for the operation of blood-letting. See n° 131.

Fig. 9. A jugum cervicis recommended by some practitioners in venesection in the neck. See n° 137.

Fig. 10. A bandage for making compression after performing the operation of arteriotomy at the temples. See n° 145.

Fig. 11. A scarificator with 16 lancets, used in the operation of cupping. See n° 146.

Fig. 12. A cupping-glass. See n° 147.

Fig. 13. A seton needle. See n° 153.

Fig. 14. The common crooked needle used in making sutures. See n° 154.

Fig. 15. *a, b*, Two pins of different forms used in the twisted

Explan-
ation of the
Plates.

Explan-
ation of the
Plates.

twisted or hare-lip future. The first commonly made of silver, with a movable steel point; the other of gold. See n° 157.

Fig. 16. The tourniquet now most generally used. See n° 160.

Fig. 17. The tenaculum used in securing the mouths of bleeding vessels. See n° 162.

Fig. 18. A common scalpel. See n° 174.

Fig. 19. A large lancet used for opening cavities of different kinds. See n° 174.

Fig. 20. A blunt-pointed bistoury. See n° 174.

PLATE CCCCLXXXVIII. Fig. 21. A raspatory for removing the pericranium in the operation of the trepan. See n° 186.

Fig. 22. The trephine with all its parts connected and ready for use. *a*, The centre-pin, which can be raised or depressed by the slider *b*. *c*, The part where the saw is united to the handle by means of the spring *d*. See n° 186.

Fig. 23. Handle of the trepan into which the head of the trephine is to be inserted at *a*. See n° 186.

Fig. 24. A perforator, which can be joined to the handle either of the trephine or trepan. See n° 186.

Fig. 25. A brush for cleaning the teeth of the saw. See n° 186.

Fig. 26. Forceps for removing the piece of bone when nearly cut through by the trephine or the trepan. See n° 186.

Fig. 26. *a*, A levator also employed in removing the piece of bone. See n° 186.

Fig. 26. *b*, Lenticular for smoothing the ragged edge of the perforated bone. See n° 186.

Fig. 27. A common probe. See n° 187.

Fig. 28. A directory. See n° 187.

Fig. 29. A speculum used for keeping the eyelids separated, and the eye fixed, in performing various operations upon that organ. See n° 205.

Fig. 30. A flat curved hook for elevating the upper eyelid, and fixing the eye, in performing various minute operations upon its surface. See n° 205.

Fig. 31. A couching needle. See n° 216.

Fig. 32. A couching needle for the right eye, fitted for the operator's right hand. See n° 217.

Fig. 33. A knife for extracting the cataract. See n° 218.

Fig. 34. A flat probe for scratching the capsule in extracting the crystalline lens. See n° 218.

Fig. 35. A flat probe or scoop for assisting in removing the cataract. See n° 218.

Fig. 36. A knife for extracting the cataract from the right eye. See n° 218.

Fig. 37. One of Anel's probes for removing obstructions of the lachrymal ducts. See n° 224.

Fig. 38. A syringe and pipe (by the same) for injecting a liquid into the lachrymal ducts. See n° 224.

Fig. 38. *a*, A crooked pipe which fits the syringe. See n° 224.

Fig. 39. An instrument for compressing the lachrymal sac. See n° 226.

Fig. 40. A trocar and canula for perforating the os unguis in the operation for fistula lachrymalis. See n° 229.

Fig. 41, 42, 43. Instruments employed by Mr Pellier in the operation for fistula lachrymalis. Fig. 41. A conductor for clearing the nasal duct. Fig. 42. A conical tube to be left in the duct. Fig. 43. A compressor for fixing the tube in its place. See n° 230.

Fig. 44. A trocar for making an artificial parotid duct. See Chap. XVI. Sect. i.

Fig. 45. Forceps sometimes used for laying hold of the lip in the operation for hare-lip. See n° 231.

Fig. 46. A pair of strong scissors used in the operation for hare-lip. See n° 231.

Fig. 47. Pins used in the operation for hare-lip. See n° 231.

Fig. 48. Gum-phleme. See n° 232.

Fig. 49. A trocar for perforating the antrum maxillare. See Chap. XVI. Sect. vi.

Fig. 50. An instrument of a tubular form for perforating the antrum maxillare. See as directed in Fig. 49.

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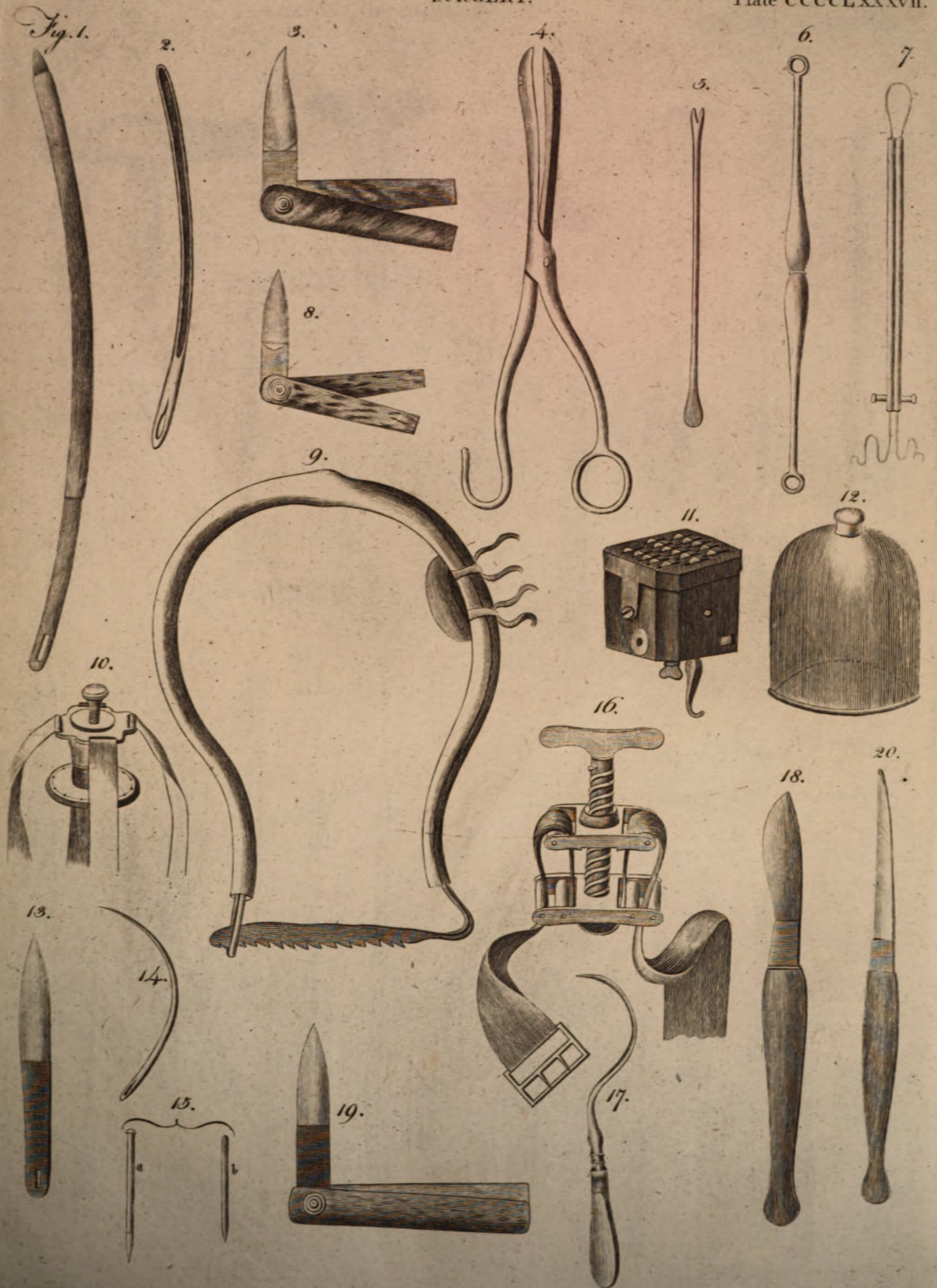


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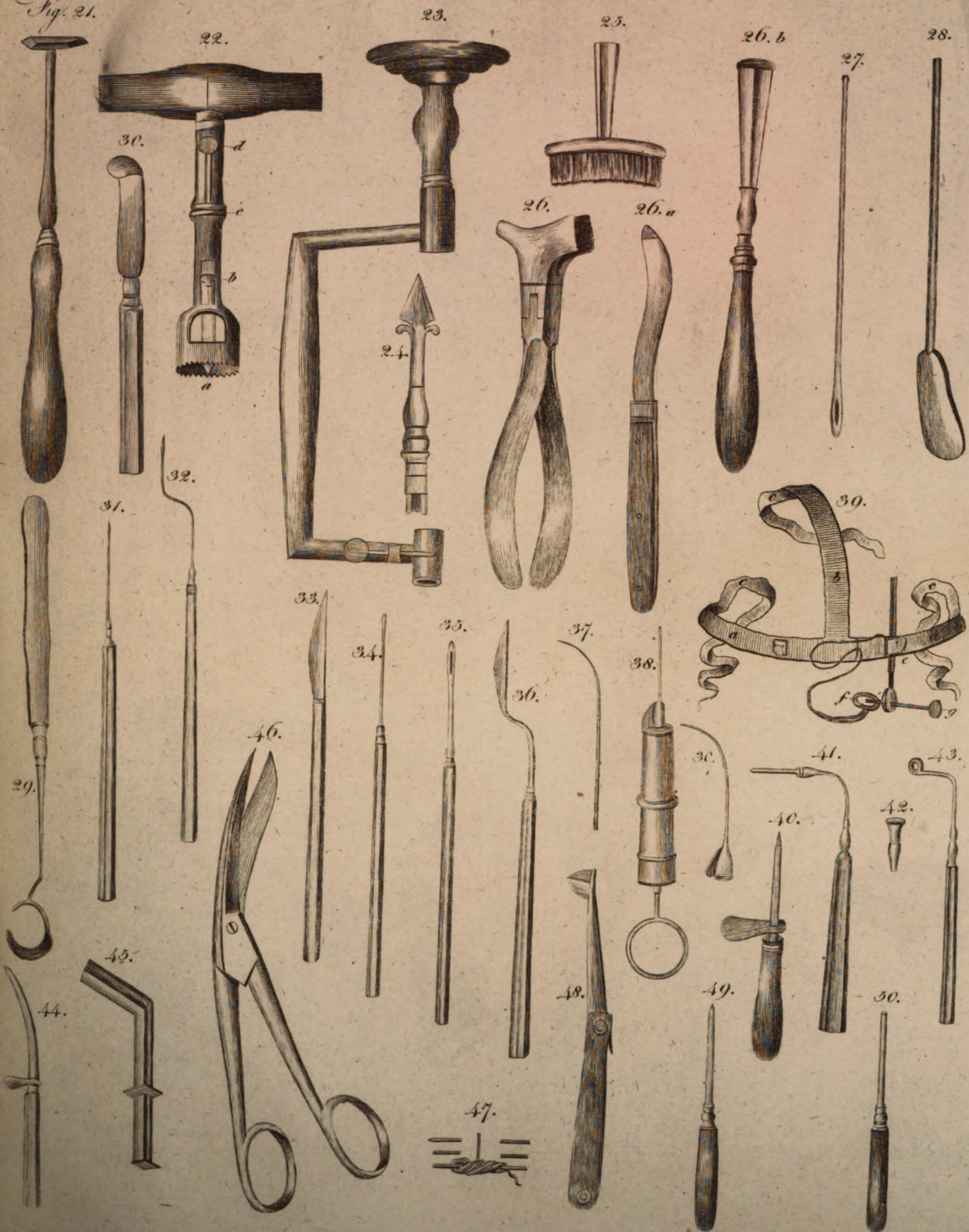


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A Bell Prin. Mat. Sculptor fecit.

Wm. A. Wood, London, 1840.

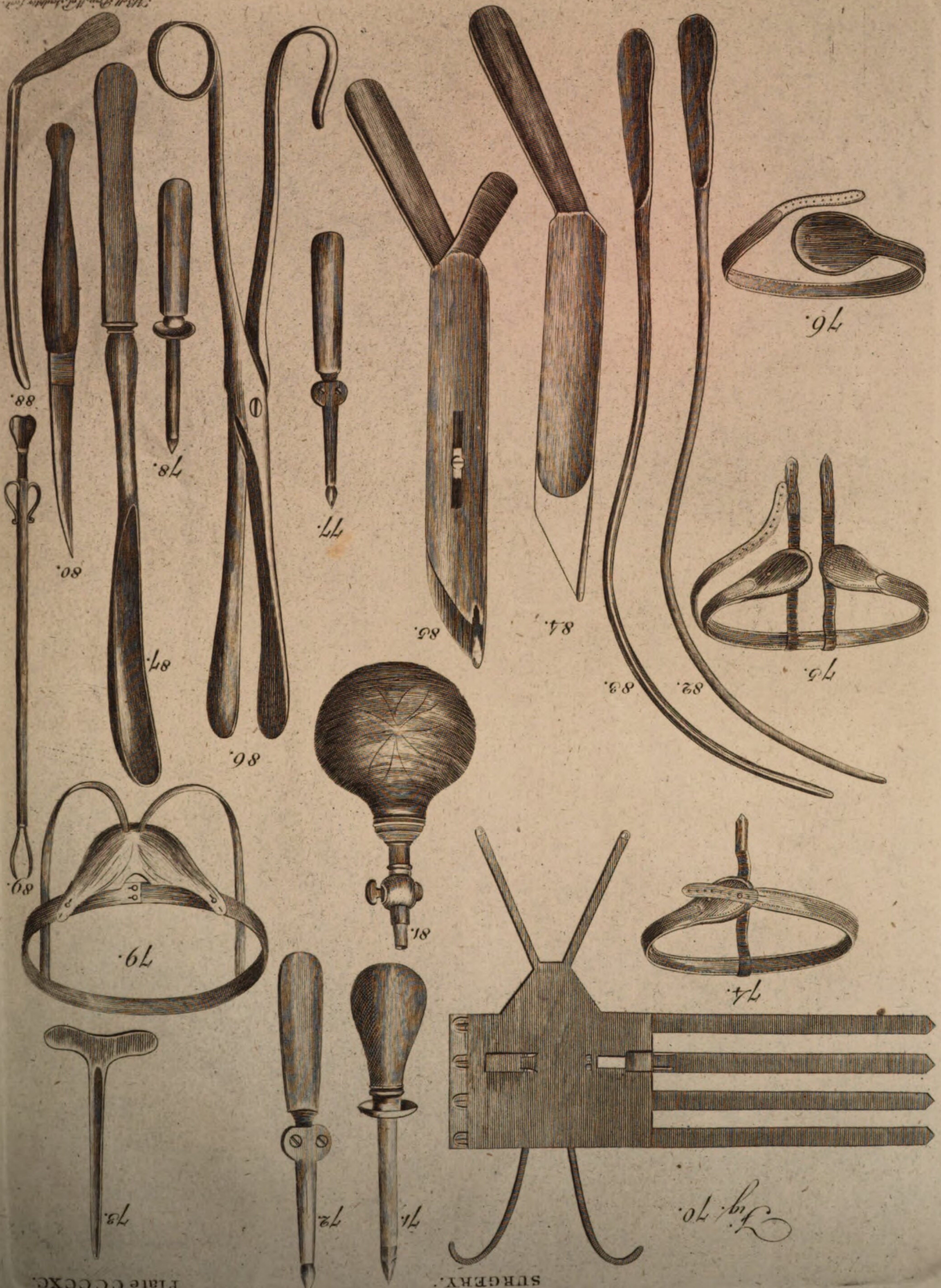


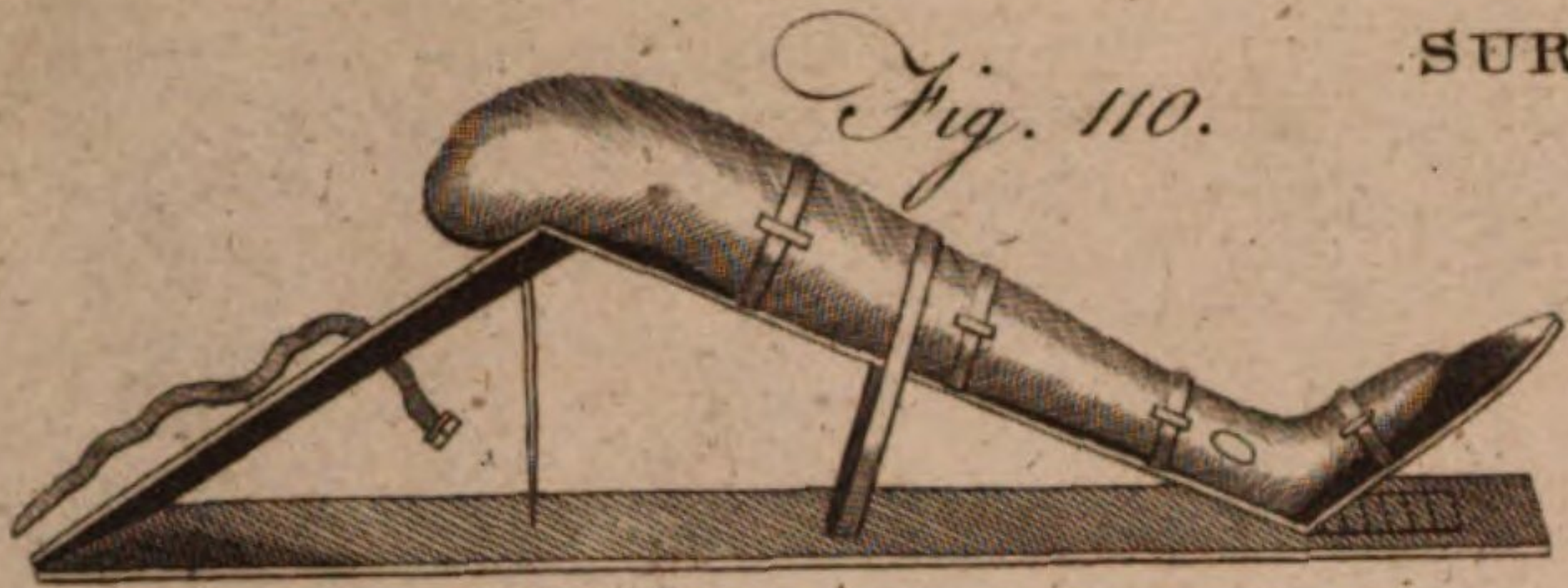
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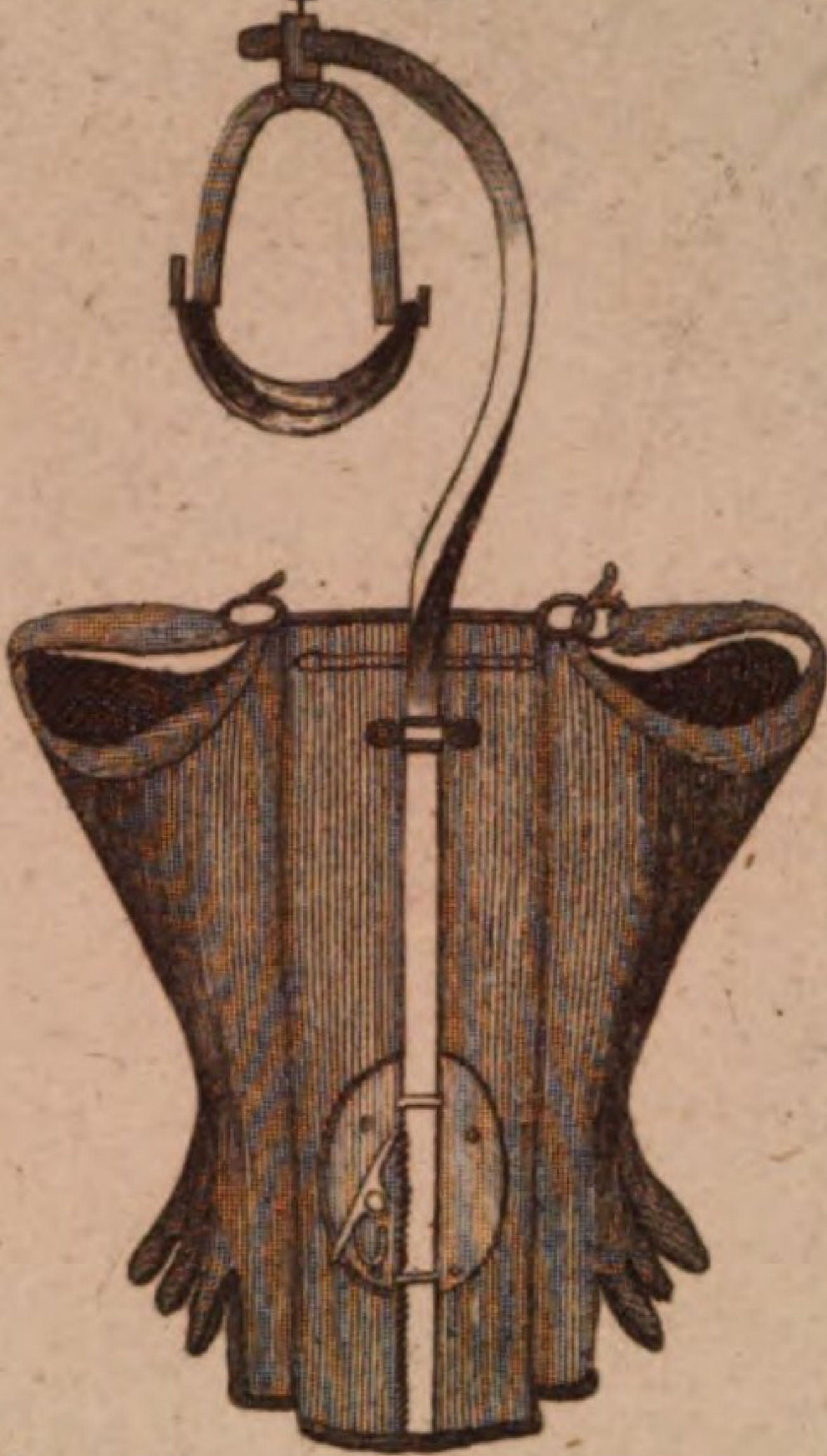
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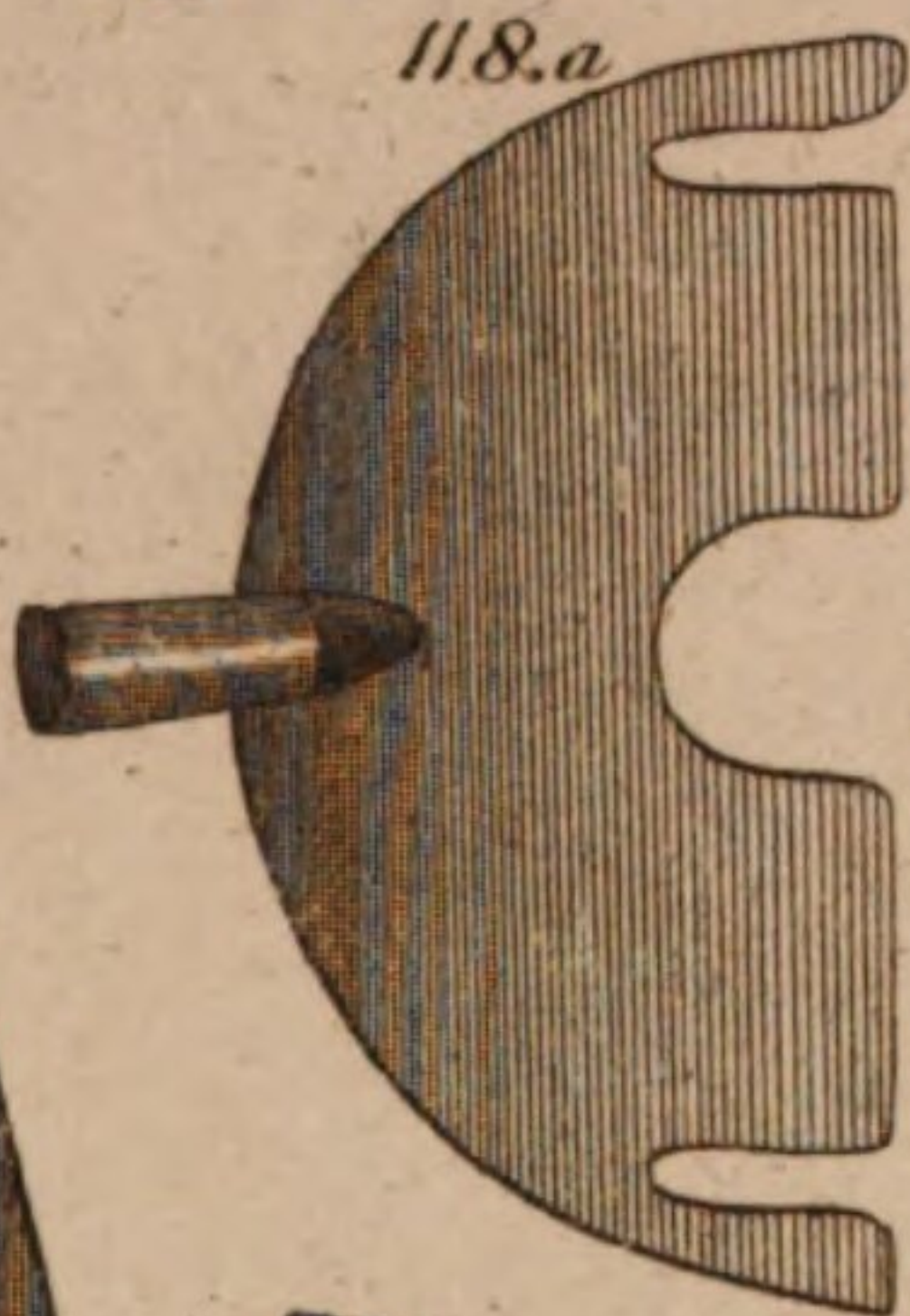
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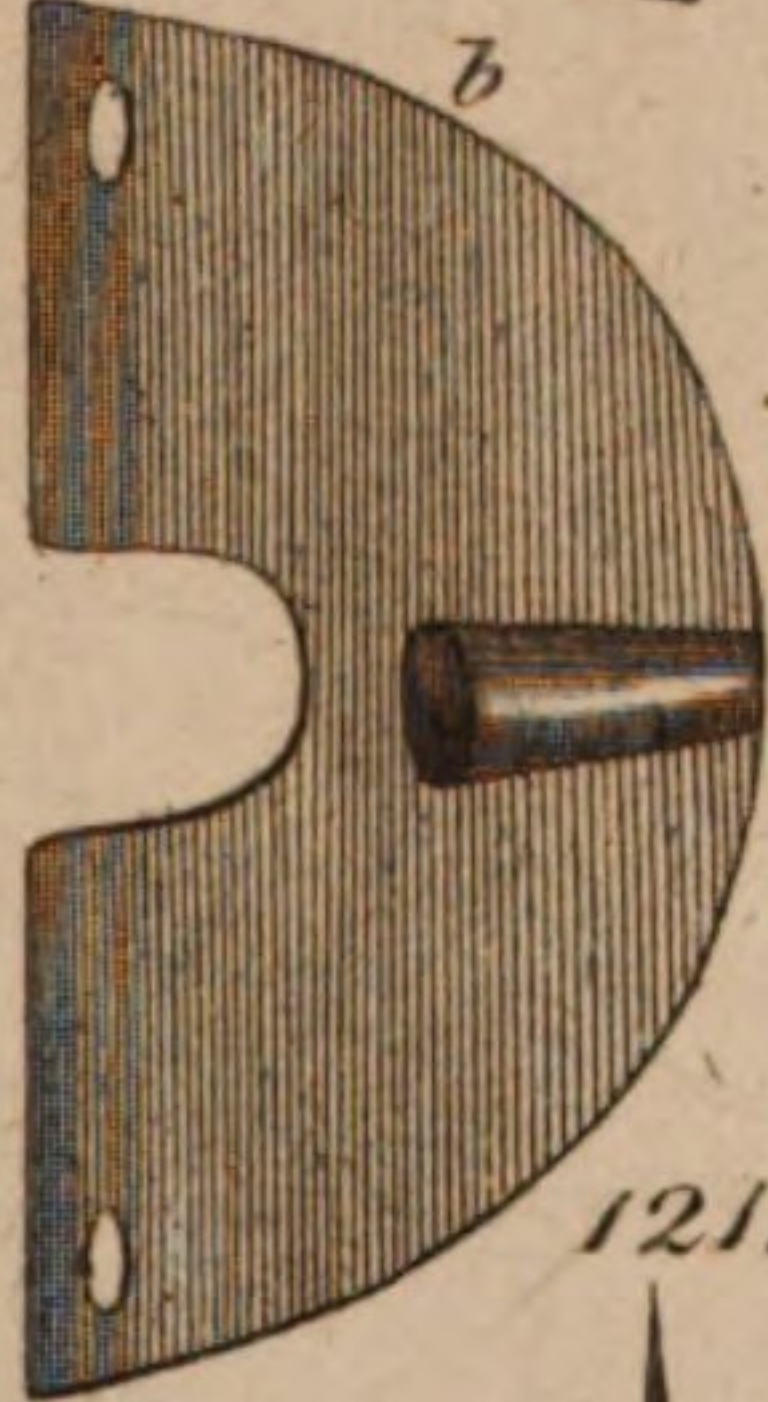
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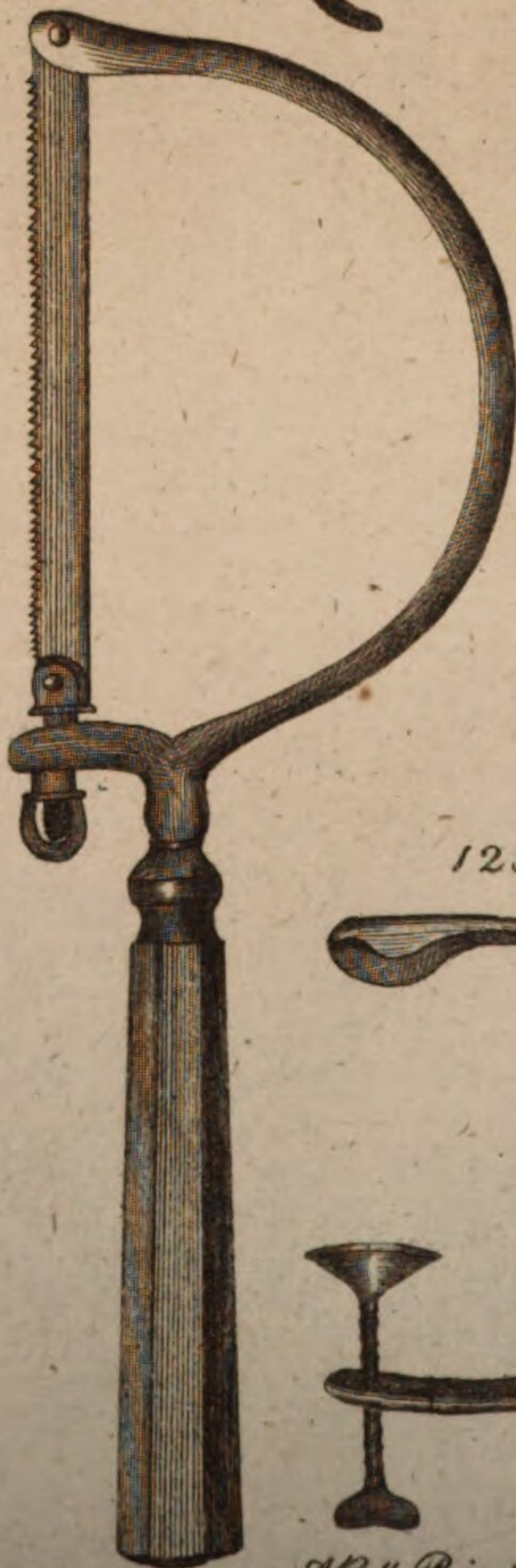
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Wounds, simple, ch. ii. sect. i. Mortal, 7. Of the Skin and cellular substance, 9. Of the muscles, 10. Of the arteries, ligaments, nerves, and tendons, 11, 12. Of the thorax and its viscera, 13, 25. Of the abdomen and its viscera, 14. Treatment of, 15, 16, and 26. Hemorrhages from, 17. Of the head, 27. Of the joints, 28. Contused and lacerated, 29. Gun-shot, ch. ii. sect. iii. Poisoned, proceeding from the bite of animals, n° 37, 38. Of the eyelids, 198. Of the eyeball, 199.
Wrist, luxation of the bones at, n° 378. Fracture of the bones at, 395. Amputation, 414.

Surinam
||
Surname.

SURINAM, the capital of the Dutch settlements in Guiana, situated on a river of the same name, in N. Lat. 6. 16. W. Long. 56. 0. It gives name to the country for 100 miles round; and stands on a river of the same name, which is navigable for 30 leagues up the country. A settlement was formed at Surinam in 1650 by the Dutch, who preserved possession of it ever since. The chief trade consists in sugar, cotton, coffee of an excellent kind, tobacco, flax, skins, and some valuable drugs for dyeing. Four hundred and thirty plantations have been already formed on the banks of the Surinam and the adjacent country, which in 1775 yielded 24,120,000 weight of rough sugar, which were sold in Holland for 347,225 l. Sterling; 15,000,387 lb. weight of coffee, which sold for 357,538 l.; 970,000 lb. weight of cotton; 790,854 lb. weight of cocoa; 152,844 lb. weight of wood for dyeing. The sum total of these productions amounted to 822,905 Sterling, and was brought into the harbours of the republic in 70 vessels. The number of slaves employed in the same year was 60,000, who belonged to 2824 masters, exclusive of the women and children. The white people were of different countries and different religions.

Raynal's
History of
the Settlements and
Trade of the
East and
West Indies.

Connected with Surinam, we may mention the colonies of Demerary, Isequeibo, and Berbice, which lie a little to the west. The two first surrendered to the British troops in 1781; but being left defenceless, were retaken by a French frigate. Demerary has lately been taken a second time by the army of Great Britain. It is considered as a valuable acquisition, being a flourishing colony. In 1769 there were established on the banks of the Demerary 130 habitations, in which sugar, coffee, and cotton were successfully cultivated, and since that period the number of plantations hath increased much.

Isequeibo is a very inconsiderable settlement. Berbice, which lies between Demerary and Surinam, contains about 104 plantations, most of them small, and scattered at great distances from one another upon the banks of the Berbice or of Conje. When Raynal published the last edition of his History of Settlements and Trade in the East and West Indies, the population consisted of 7000 slaves of every age and sex, 250 white men, exclusive of the soldiers. The coffee, sugar, and cotton produced was conveyed to Holland in four or five ships, and sold for about 40 or 50,000 l.

SURMOUNTED, in heraldry, is when one figure is laid over another.

SURMULLET. See **MULLUS**.

SURNAME, that which is added to the proper name for distinguishing persons and families. It was originally distinguished from *surname*, which denotes the name of the sire or progenitor: thus, Macdonald, Robertson are surnames expressing the son of Donald, the son of Robert. The word *surname*, again, signified some name superadded to the proper name to distinguish the individual, as Artaxerxes Longimanus, Harold Harefoot, Malcolm Canmore. From this it is evident that every surname was a surname, though the reverse was not so. In modern times they are confounded; and as there is now no occasion to preserve the distinction, Dr Johnson has rejected the word *surname* altogether. See **NAME**.

Surnames were introduced among all nations at an early

period, and seem to have been formed at first by adding the name of the father to that of the son. This was the practice among the Hebrews, as appears from the scriptures. Caleb is denominated the son of Jephunneh, and Joshua the son of Nun. That the same thing was customary among the Greeks, every one who has read the poems of Homer must remember. We have an instance of it in the very first line of the Iliad: *Ἀχιλλεύς Πηληϊάδῃ*, "Achilles the son of Peleus." This is perhaps the general origin of surnames, for it has been common among most nations (A).

The Romans generally had three names. The first called *prænomen* answered to our Christian name, and was intended to distinguish the individuals of the same family; the second called *nomen* corresponded to the word *clan* in Scotland, and was given to all those who were sprung from the same stock; the third called *cognomen* expressed the particular branch of the tribe or clan from which an individual was sprung. Thus Publius Cornelius Scipio, *Publius* corresponded to our names John, Robert, William; *Cornelius* was the name of the clan or tribe, as Campbell was formerly the name of all the Duke of Argyle's clients, and Douglas the name of the retainers of the Duke of Hamilton's progenitors. *Scipio* being added, conveyed this information, that Publius, who was of the tribe of the Cornelii, was of the family of the Scipios, one of the branches or families into which that tribe was divided. Respecting the three names which were common among the Romans, we may say that the first was a name and the other two surnames.

Du Chesne observes, that surnames were unknown in France before the year 987, when the lords began to assume the names of their demesnes. Camden relates, that they were first taken up in England, a little before the conquest, under King Edward the Confessor: but he adds, they were never fully established among the common people till the time of Edward II.; till then they varied with the father's name; if the father, *e. gr.* was called *Richard*, or *Roger*, the son was called *Richardson*, or *Hodgson*; but from that time they were settled, some say, by act of parliament. The oldest surnames are those we find in Domesday-Book, most of them taken from places, with the addition of *de*; as Godefridus *de* Mannevilla, Walterus *de* Vernon, Robert *de* Oyly, &c. Others from their fathers, with *filius*, as Gulielmus *filius* Osberni; others from their offices, as Eudo *Dapifer*, Gulielmus *Camerarius*, Gislebertus *Cocus*, &c. But the inferior people are noted simply by their Christian names, without any surnames at all.

They seem to have been introduced into Scotland in the time of William the Conqueror by the English who accompanied Edgar Atheling when he fled into that kingdom. These had their proper surnames, as Moubay, Lovell, Lisle, using the particle *de* before them; which makes it probable that these surnames had been derived from the lands which their ancestors or they themselves had possessed. In Kenneth II's time in 800 the great men had indeed begun to call their lands by their own names; but the ordinary distinctions then used were only personal, and did not descend to succeeding generations, such as those employed by the Hebrews and Greeks: For example, *John the son of William*; or the names of office, as *Stewart*; or accidental distinctions from complexion or station, as *Black*, *White*;

(A) This might be supported by examples borrowed from many nations. The old Normans used *Fitz*, which signifies son; as Fitzherbert, Fitzsimmons, the son of Herbert, the son of Simmons. The Irish used *O*; as O'Neal, the son of Neal. The Scotch Highlanders employed *Mac*; as Macdonald, the son of Donald. The Saxons added the word *son* to the end of the father's name, as Williamson.

Surname White, Long, Short; or the name of their trade, as Taylor, Weaver.
Surrender

It was long before any surnames were used in Wales, except that of son, as Evan ap Rice, Evan the son of Rice; Evan ap Howel, Evan the son of Howel: but many of them have at length formed separate surnames, as the English and Scots, by leaving out the *a* in *ap*, and joining the *p* to the father's name: thus Evan ap Rice becomes Evan Price; Evan ap Howel, Evan Powel.—We are told, surnames were unknown in Sweden till the year 1514, and that the common people of that country use none to this day; and that the same is the case with the vulgar Irish, Poles, and Bohemians.

When we come to inquire into the etymology of surnames, we must allow that many of them were originally significant of the qualities of mind, as Bold, Hardy Meek; some of the qualities of body, as Strong, Low, Short; others expressive of the trade or profession followed by the persons to whom they were applied, as Baker, Smith, Wright; Butler, Page, Marshal. But the greatest number, at least of the ancient surnames, were borrowed from the names of places. Camden says, that there is not a village in Normandy but has given its name to some family in England. He mentions as examples, Percy, Devereux, Tankervil, Mortimer, Warren, &c. They were introduced with William the Conqueror. Several have been derived from places in the Netherlands, as Gaunt, Tournay, Grandison; and many from the names of towns and villages in England and Scotland, as Wentworth, Markham, Murray, Aberdeen. Many have been formed from the names of animals, as quadrupeds, birds, fishes; from vegetables, and parts of vegetables, as trees, shrubs, flowers, and fruits; from minerals of different kinds. Others are formed from such a variety of accidents that it is impossible to particularize them.

SURPLICE, the habit of the officiating clergy in the church of England. By Can. 38, every minister saying the public prayers, or ministering the sacrament or other rites of the church, shall wear a decent and comely surplice with sleeves, to be provided at the charge of the parish. But by 1 Eliz. c. 2. and 13 and 14 Car. II. the garb prescribed by act of parliament, in the second year of king Edward the Sixth, is enjoined; and this requires that in the saying or singing of matins and even songs, baptizing and burying, the minister in parish churches and chapels shall use a surplice. And in all cathedral churches and colleges, the archdeacon, dean, provosts, masters, prebendaries, and fellows, being graduates, may use in the choir, besides their surplices, such hoods as pertain to their several degrees. But in all other places every minister shall be at liberty to use a surplice or not. And hence in marrying, churching of women, and other offices not specified in this rubric, and even in the administration of the holy communion, it seems that a surplice is not necessary. Indeed for the holy communion the rubric appoints a white ALB plain, which differs from the surplice in being close-sleeved, with a vestment or cope.

SURREBUTTER, in law, is second rebutter; or the replication of the plaintiff to the defendant's rebutter.

SURREJOINDER, is a second defence of the plaintiff's declaration, by way of answer to the defendant's rejoinder.

SURRENDER, in common law, a deed or instrument, testifying that the particular tenant of lands and tenements, for life or years, doth sufficiently consent and agree, that he who has the next or immediate remainder or reversion thereof, shall have the present estate of the same in possession; and that he hereby yields and gives up the same to him, so that the estate for life or years may merge or drown

by mutual agreement of the parties. Of surrenders there are three kinds; a surrender properly taken at common law; a surrender of copyhold or customary estates; and a surrender improperly taken, as of a deed, a patent, &c. The first is the usual surrender, and it is usually divided into that in deed, and that in law.

SURRENDER, in deed, is that which is really made by express words in writing, where the words of the lessee to the lessor prove a sufficient assent to surrender his estate back again.

SURRENDER, in law, is that wrought by operation of the law, and which is not actual.—As if a man have a lease of a farm for life or years, and during the term he accepts a new lease; this act is, in law, a surrender of the former.

SURRENDER of a bankrupt. See *COMMISSION of Bankruptcy*.

SURRENDER of Copyholds is the yielding up of the estate by the tenant into the hands of the lord, for such purposes as are expressed in the surrender: as to the use and behoof of A and his heirs, to the use of his own will, and the like. This method of conveyance is so essential to the nature of a copyhold estate, that it cannot possibly be transferred by any other assurance. No feoffment, fine, or recovery (in the king's courts) hath any operation upon it. If I would exchange a copyhold with another, I cannot do it by an ordinary deed of exchange at the common law, but we must surrender to each other's use, and the lord will admit us accordingly. If I would devise a copyhold, I must surrender it to the use of my last will and testament; and in my will I must declare my intentions, and name a devisee, who will then be entitled to admission.

SURRENDER of Letters Patent and Offices. A surrender may be made of letters patent to the king, so that he may grant the estate to whom he pleases, &c. and a second patent for years to the same person for the same thing is a surrender in law of the first patent. 10 Rep. 66. If an officer for life accepts of another grant of the same office, it is in law a surrender of the first grant; but if such an officer takes another grant of the same office to himself and another, it may be otherwise.

SURREPTITIOUS. See *SURREPTITIOUS*.

SURROGATE, in law, denotes a person that is substituted or appointed in the room of another.

SURRY, a county of England, bounded on the west by Berkshire and Hampshire, on the south by Sussex, on the east by Kent, on the north by Middlesex, from which it is parted by the Thames, whence it had the name of *Sub-rey* from the Saxons, i. e. the country on the south side of the river. It is 38 miles in length from east to west, 23 in breadth from north to south, and 112 in circumference. It contains 13 hundreds, 140 parishes, of which 35 are vicarages, 13 market-towns, 450 villages, 592,000 acres, and about 170,000 inhabitants. The members sent from it to parliament are 14, of which two are sent by each of the following boroughs, viz. Southwark, Bleachingley, Ryegate, Guildford, Gatton, Haslemere, and two for the county.

The air of this county, towards the middle, which consists mostly of hills and heath, is sharp, but pure and wholesome. About the skirts, where it is more level, and the soil richer, the air is milder, but also salubrious. In the middle parts the soil is barren enough in general; but towards the extremities, and where the country is open and champaign, it is fruitful in grass and corn, particularly on the south side in Holmsdale, in which meadows, woods, and corn-fields, are agreeably intermixed. The soil is also very fertile along the Thames, especially towards London, where it greatly contributes to maintain plenty in the London

Sur-solid
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don markets. It has several rivers, abounding with fish, the chief of which are the Wye, the Mole, and the Wandle.

SURSOLID, or **SURDESOLID**, in arithmetic, the fifth power of a number, or the fourth multiplication of any number, considered as a root.

SURVEYING, the art of measuring land; that is, of taking the dimensions of any tract of ground, laying down the same in a map or draught, and finding the content or area thereof. See **GEOMETRY**.

SURVEYOR, a person who has the oversight and care of considerable works, lands, or the like.

SURVEYOR, likewise denotes a gauger; as also a person who surveys lands, and makes maps of them.

SURVIVOR, in law, signifies the longest liver of joint tenants, or of any two persons jointly interested in a thing.

SURVIVORSHIP, is that branch of mathematics which treats of reversions payable provided one or more particular persons survive certain others. By reversions are meant payments not to take place till some future period. Survivorship forms one of the most difficult and complicated parts of the doctrine of reversions and life-annuities. It has been very fully treated of by Mr Thomas Simpson in his *Select Exercises*; and brought to a state of very great perfection by Dr Price and Mr Morgan, who have bestowed a great deal of attention on this subject.

The calculations are founded on the expectation of lives at different ages, deduced from tables formed from bills of mortality, of which see several examples under the article *Bills of MORTALITY*. By the expectation of life is meant the mean time that any single or joint lives at a given age is found to continue; that is, the number of years which, taking one with another, they actually enjoy, and may be considered as sure of enjoying; those who survive that period enjoying as much more time in proportion to their number as those who fall short of it enjoy less. Thus, supposing 46 persons alive all 40 years of age, and that one will die every year till they are all dead in 46 years, half 46 or 23 will be the expectation of each of them. If M. de Moivre's hypothesis were true, that men always decrease in an arithmetical progression, the expectation of a single life is always half its complement (A), and the expectation of two joint lives one-third of their common complement. Thus, supposing a man 40, his expectation would be 23, the half of 46, his complement; the expectation of two joint lives, each 40, would be 15 years 4 months, or the third part of 46.

The number expressing the expectation, multiplied by the number of single or joint lives (of which it is the expectation), added annually to a society, gives the whole number living together, to which such an annual addition would in time grow. Thus, since 19, or the third of 57, is the expectation of two joint lives, whose common age is 29, twenty marriages every year between persons of this age would in 57 years grow to 20 times 19, or 380 marriages, always existing together. And since the expectation of a single life is always half its complement, in 57 years 20 single persons added annually to a town will increase to 20 times 28.5, or 570; and when arrived at this number, the deaths every year will just equal the accessions, and no farther increase be possible. It appears from hence, that the particular proportion that becomes extinct every year, out of the whole number constantly existing together of single or joint lives, must, wherever this number undergoes no variation, be exactly the same with the expectation of those lives, at the time when their existence commenced. Thus, was it found that a 19th part of all the marriages among any bodies of men, whose

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numbers do not vary, are dissolved every year by the deaths of either the husband or wife, it would appear that 19 was, at the time they were contracted, the expectation of these marriages. In like manner, was it found in a society, limited to a fixed number of members, that a 28th part dies annually out of the whole number of members, it would appear that 28 was their common expectation of life at the time they entered. So likewise, were it found in any town or district, where the number of births and burials are equal, that a 20th or 30th part of the inhabitants die annually, it would appear that 20 or 30 was the expectation of a child just born in that town or district. These expectations, therefore, for all single lives, are easily found by a table of observations, showing the number that die annually at all ages out of a given number alive at those ages; and the general rule for this purpose is, to divide the sum of all the living in the table, at the age whose expectation is required, and at all greater ages, by the sum of all that die annually at that age and above it; or, which is the same, by the number (in the Table) of the living at that age; and half unity subtracted from the quotient will be the required expectation. Thus, in Dr Halley's table, given in the article *ANNUITY*, the sum of all the living at 20 and upwards is 20,724, which, divided by 598, the number living at the age of 20, and half unity subtracted from the quotient, gives 34.15 for the expectation of 20.

In calculating the value or expectation of joint lives, Mr de Moivre had recourse to the hypothesis, that the probabilities of life decrease in a geometrical progression; believing that the values of joint lives, obtained by rules derived from it, would not deviate much from the truth. But in this he was greatly mistaken; they generally give results which are near a quarter of the true value too great in finding the present value of one life after it has survived another in a single payment, and about $\frac{2}{3}$ ths too great when the value is sought in annual payments during the joint lives. They ought therefore to be calculated upon the hypothesis (if they are calculated on hypothesis at all), that the probabilities of life decrease in arithmetical progression, which is not very far from the truth. Even this hypothesis never corresponds with the fact in the first and last periods of life, and in some situations not in any period of life. Dr Price and Mr Morgan therefore have given tables of the value of lives, not founded on any hypothesis, but deduced from bills of mortality themselves. Some of these we shall give at the end of this article. Mr Morgan has likewise given rules for calculating values of lives in this manner.

M. de Moivre has also fallen into mistakes in his rules for calculating the value of reversions depending on survivorship: these have been pointed out by Dr Price in the third essay in the first volume of his *Treatise on Reversionary Payments*; who has also given proper rules for calculating these values, the most important of which are comprehended in the following paragraphs.

Suppose a set of married men to enter into a society in order to provide annuities for their widows, and that it is limited to a certain number of members, and constantly kept up to that number by the admission of new members as the old ones are lost; it is of importance, in the first place, to know the number of annuitants that after some time will come upon the establishment. Now since every marriage produces either a widow or widower; and since all marriages taken together would produce as many widows as widowers, were every man and his wife of the same age, and the chance equal which shall die first; it is evident, that the

B b

number

(A) By the complement of a life is meant what it wants of 86, which M. de Moivre makes the boundary of human life. Thus if a man be 30, the complement of his life is 56.

Survivor-
ship.

number of widows that have ever existed in the world, would in this case be equal to half the number of marriages. And what would take place in the world must also, on the same suppositions, take place in this society. In other words, every other person in such a society leaving a widow, there must arise from it a number of widows equal to half its own number. But this does not determine what number, all living at one and the same time, the society may expect will come to be constantly upon it. It is, therefore, necessary to determine how long the duration of survivorship between persons of equal ages will be compared with the duration of marriage. And the truth is, that, supposing the probabilities of life to decrease uniformly, the former is equal to the latter; and consequently that the number of survivors, or (which is the same, supposing no second marriages) of widows and widowers alive together, which will arise from any given set of such marriages constantly kept up, will be equal to the whole number of marriages; or half of them (the number of widows in particular) equal to half the number of marriages. Now it appears that in most towns the decrease in the probabilities of life is in fact nearly uniform. According to the Breslaw Table of Observation (see ANNUITY), almost the same numbers die every year from 20 years of age to 77. After this, indeed, fewer die, and the rate of decrease in the probabilities of life is retarded. But this deviation from the hypothesis is inconsiderable; and its effect, in the present case, is to render the duration of survivorship longer than it would otherwise be. According to the London Table of Observations, the numbers dying every year begin to grow less at 50 years of age; and from hence to extreme old age there is a constant retardation in the decrease of the probabilities of life. Upon the whole, therefore, it appears that, according to the Breslaw Table, and supposing no widows to marry, the number inquired after is somewhat greater than half the number of the society; but, according to the London Table, a good deal greater. This, however, has been determined on the supposition that the husbands and wives are of equal ages, and that then there is an equal chance who shall die first. But in reality husbands are generally older than wives, and males have been found to die sooner than females, as appears incontestably from several of the tables in Dr Price's Treatise on Reversions. It is therefore more than an equal chance that the husband will die before his wife. This will increase considerably the duration of survivorship on the part of the women, and consequently the number which we have been inquiring after. The marriage of widows will diminish this number, but not so much as the other causes will increase it.

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When the
number of
annuitants
arrives at
its maxi-
mum.

If the society comprehends in it from the first all the married people of all ages in any town, or among any class of people where the numbers always continue the same, the whole collective body of members will be at their greatest age at the time of the establishment of the society; and the number of widows left every year will at a medium be always the same. The number of widows will increase continually on the society, till as many die off every year as are added. This will not be till the whole collective body of widows are at their greatest age, or till there are among them the greatest possible number of the oldest widows; and therefore not till there has been time for an accession to the oldest widows from the youngest part.

Let us, for the sake of greater precision, divide the whole medium of widows that come on every year into different classes according to their different ages, and suppose some to be left at 56 years of age, some at 46, some at 36, and some at 26. The widows, constantly in life together, derived from the first class, will come to their greatest age,

and to a *maximum*, in 30 years, supposing, with M. de Moivre, 86 to be the utmost extent of life. The same will happen to the second class in 40 years, and to the third in 50 years. But the whole body composed of these classes will not come to a *maximum* till the same happens to the fourth or youngest class; that is, not till the end of 60 years. After this the affairs of the society will become stationary, and the number of annuitants upon it of all ages will keep always nearly the same.

If a society begins with its complete number of members, but at the same time admits none above a particular age: If, for instance, it begins with 200 members all under 50, and afterwards limits itself to this number, and keeps it up by admitting every year, at all ages between 26 and 50, new members as old ones drop off; in this case, the period necessary to bring on the *maximum* of annuitants will be just doubled.

To determine the sum that every individual ought to pay in a single present payment, in order to intitle his widow to a certain annuity for her life, let us suppose the annuity 31 *per annum*, and the rate of interest four *per cent*. It is evident, that the value of such an expectation is different, according to the different ages of the purchasers, and the proportion of the age of the wife to that of the husband. Let us then suppose that every person in such a society is of the same age with his wife, and that one with another all the members when they enter may be reckoned 40 years of age, as many entering above this age as below it. It has been demonstrated by M. de Moivre and Mr Simpson, that the value of an annuity on the joint continuance of any two lives, subtracted from the value of an annuity on the life in expectation, gives the true present value of an annuity on what may happen to remain of the latter of the two lives after the other.

In the present case, the value of an annuity to be enjoyed during the joint continuance of two lives, each 40, is, by Table II. 9.826, according to the probabilities of life in the Table of Observations formed by Dr Halley from the bills of mortality of Breslaw in Silesia. The value of a single life 40 years of age, as given by M. de Moivre, agreeably to the same table, is 13.20; and the former subtracted from the latter, leaves 3.37, or the true number of years purchase, which ought to be paid for any given annuity, to be enjoyed by a person 40 years of age, provided he survives another person of the same age, interest being reckoned at four *per cent. per annum*. The annuity, therefore, being 30 l. the present value of it is 30 multiplied by 3.37, or 101 l. 2 s.

If, instead of a single present payment, it is thought preferable to make annual payments during the marriage; what these annual payments ought to be is easily determined by finding what annual payments during two joint lives of given ages are equivalent to the value of the reversionary annuity in present money. Suppose, as before, that the joint lives are each 40, and the reversionary annuity 30 l. *per annum*. An annual payment during the continuance of two such lives is worth (according to Table II.) 9.82 years purchase. The annual payment ought to be such as, being multiplied by 9.82, will produce 101.1 l. the present value of the annuity in one payment. Divide then 101.1 by 9.82, and 10.3 the quotient will be the annual payment. This method of calculation supposes that the first annual payment is not to be made till the end of a year. If it is to be made immediately, the value of the joint lives will be increased one year's purchase; and therefore, in order to find the annual payments required, the value of a present single payment must be divided by the value of the joint lives increased by unity. If the society prefer paying part of the value in a present single payment on admission, and the rest in annual payments; and if they fix these annual payments

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What he
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Survivor-
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at a particular sum, the present single payment paid on admission is found by subtracting the value of the annual payment during the joint lives from the whole present value of the annuity in one payment. Suppose, for instance, the annual payments to be fixed at five guineas, the annuity to be 30 l. the rate of interest four *per cent.* and the joint lives each 40; the value of the annuity in one present single payment is 101.1 l. The value of five guineas or 5.25 *per annum*, is (5.25 multiplied by 9.82 the value of the joint lives) 51.55; which, subtracted from 101.1 l. gives 1.49.5, the answer.

If a society takes in all the marriages among persons of a particular profession within a given district, and subjects them for perpetuity to a certain equal and common tax or annual payments, in order to provide life annuities for all the widows that shall result from these marriages; since, at the commencement of such an establishment, all the oldest, as well as the youngest, marriages are to be intitled equally to the proposed benefit, a much greater number of annuitants will come immediately upon it than would come upon any similar establishment which limited itself in the admission of members to persons not exceeding a given age. This will check that accumulation of money which should take place at first, in order to produce an income equal to the disbursements at the time when the number of annuitants comes to a *maximum*; and therefore will be a particular burden upon the establishment in its infancy. For this some compensation must be provided; and the equitable method of providing it is, by levying fines at the beginning of the establishment on every member exceeding a given age, proportioned to the number of years which he has lived beyond that age. But if such fines cannot be levied, and if every payment must be equal and common, whatever disparity there may be in the value of the expectations of different members, the fines must be reduced to one common one, answering as nearly as possible to the disadvantage, and payable by every member at the time when the establishment begins. After this, the establishment will be the same with one that takes upon it all at the time they marry; and the tax or annual payment of every member adequate to its support will be the annual payment during marriage due from persons who marry at the mean age at which, upon an average, all marriages may be considered as commencing. The fines to be paid at first are, for every particular member, the same with the difference between the value of the expectation to him at his present age, and what would have been its value to him had the scheme begun at the time he married. Or, they are, for the whole body of members, the difference between the value of the common expectation, to persons at the mean age of all married persons taken together as they exist in the world, and to persons at that age which is to be deemed their mean age when they marry.

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Method of
finding the
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value of an
annuity to
be enjoyed
by one life
after the
expiration
of ano-
ther.

Suppose we wish to know the present value of an annuity to be enjoyed by one life, for what may happen to remain of it beyond another life, after a given term; that is, provided both lives continue from the present time to the end of a given term of years; the method of calculating is this: Find the value of the annuity for two lives, greater by the given term of years than the given lives; discount this value for the given term; and then multiply by the probability, that the two given lives shall both continue the given term; and the product will be the answer. Thus, let the two

lives be each 30, the term seven years, the annuity 1.10, interest four *per cent.* The given lives, increased by seven years, become each 37. The value of two joint lives, each 37, is (by Table II.) 10.25. The value of a single life at 37 is (by the table under the article ANNUITY) 13.67. The former subtracted from the latter is 3.42, or the value of an annuity for the life of a person 37 years of age, after another of the same age, as has been shown above. 3.42 discounted for seven years (that is, multiplied by 0.76 the value of 1 l. due at the end of seven years) is 2.6. The probability that a single life at 30 shall continue seven years is $\frac{4}{5}$ (B). The probability, therefore, that two such lives shall continue seven years, is $\frac{2}{5}$, or in decimals 0.765; and 2.6 multiplied by 0.765 is 1.989, the number of years purchase which ought to be given for an annuity to be enjoyed by a life now 30 years of age, after a life of the same age, provided both continue seven years. The annuity then being 10 l. its present value is 1.19.89.

Suppose the value is required of an annuity to be enjoyed for what may happen to remain of one life after another, provided the life in expectation continues a given time. Find the present value of the annuity for the remainder of the life in expectation after the given time, which is done in this manner: Multiply the present value of the life at the given time by the present value of 1 l. to be received at that time, and multiply the product again by the probability that the life in expectation will continue so long. Let the given time which the life in expectation is to continue be 15 years, and let the person then be arrived at 50 years of age. A life at fifty, according to M. de Moivre's valuation of lives, and reckoning interest at four *per cent.* is worth 11.34 years purchase. The present value of 1 l. to be received at the end of 15 years, is 0.5553, and the probability that a life at 35 will continue 15 years is $\frac{1}{2}$. These three values multiplied into one another give L. 4.44 for the present value of the life in expectation. 2. Find the value of the reversion, provided both lives continue the given time, by the rule given in parag. 5th. 3. Add these values together, and the sum will be the answer in a single present payment. We shall now illustrate this rule by an example.

An annuity of 10 l. for the life of a person now 30, is to commence at the end of 11 years, if another person now 40 should be then dead; or, if this should not happen at the end of any year beyond 11 years in which the former shall happen to survive the latter: What is the present value of such an annuity, reckoning interest at four *per cent.* and taking the probabilities of life as they are in Dr Halley's table, given in the article MORTALITY?

The value of 10 l. *per annum*, for the remainder of the life of a person now 30, after 11 years is L. 69.43. The probability that a person 40 years of age shall live 11 years, is, by Dr Halley's table, $\frac{3}{4}$. The probability, therefore, that he will die in 11 years, is $\frac{1}{4}$ subtracted from unity (c), or $\frac{3}{4}$; which multiplied by 1.69.43, gives 1.17.16. The value of the reversion, provided both live 11 years, is 17 l. and this value added to the former, makes 1.34.16. the value required in a single present payment; which payment divided by 1.11.43, the value of two joint lives, aged 30 and 40, with unity added, gives 3 l.; or the value required in annual payments during the joint lives, the first payment to be made immediately.

B b 2

TABLE

(B) The probability that a given life shall continue any number of years, or reach a given age, is (as is well known) the fraction, whose numerator is the number of the living in any table of observations opposite to the given age, and denominator, the number opposite to the present age of the given life.

(c) For the difference between unity and the fraction expressing the probability that an event will happen, gives the probability that it will not happen.

Survivor-
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TABLE I. Showing the Present Values of an Annuity of L. 1 on a Single Life, according to M. de Moivre's Hypothesis.

Age.	3 per Ct.	3½ per Ct.	4 per Ct.	4½ per Ct.	5 per Ct.	6 per Ct.
8	19,736	18,160	16,791	15,595	14,544	12,790
9	19,868	18,269	16,882	15,672	14,607	12,839
10	19,868	18,269	16,882	15,672	14,607	12,839
11	19,736	18,160	16,791	15,595	14,544	12,790
12	19,604	18,049	16,698	15,517	14,480	12,741
13	19,469	17,937	16,604	15,437	14,412	12,691
14	19,331	17,823	16,508	15,356	14,342	12,639
15	19,192	17,707	16,410	15,273	14,271	12,586
16	19,050	17,588	16,311	15,189	14,197	12,532
17	18,905	17,467	16,209	15,102	14,123	12,476
18	18,759	17,344	16,105	15,015	14,047	12,419
19	18,610	17,220	15,999	14,923	13,970	12,361
20	18,458	17,093	15,891	14,831	13,891	12,301
21	18,305	16,963	15,781	14,737	13,810	12,239
22	18,148	16,830	15,669	14,641	13,727	12,177
23	17,990	16,696	15,554	14,543	13,642	12,112
24	17,827	16,559	15,437	14,442	13,555	12,045
25	17,664	16,419	15,318	14,340	13,466	11,978
26	17,497	16,277	15,197	14,235	13,375	11,908
27	17,327	16,133	15,073	14,128	13,282	11,837
28	17,154	15,985	14,946	14,018	13,186	11,763
29	16,979	15,835	14,816	13,905	13,088	11,688
30	16,800	15,682	14,684	13,791	12,988	11,610
31	16,620	15,526	14,549	13,673	12,855	11,530
32	16,436	15,367	14,411	13,553	12,780	11,449
33	16,248	15,204	14,270	13,430	12,673	11,365
34	16,057	15,039	14,126	13,304	12,562	11,278
35	15,864	14,871	13,979	13,175	12,449	11,189
36	15,666	14,699	13,829	13,044	12,333	11,098
37	15,465	14,524	13,676	12,909	12,214	11,003
38	15,260	14,345	13,519	12,771	12,091	10,907
39	15,053	14,163	13,359	12,630	11,966	10,807
40	14,842	13,978	13,196	12,485	11,837	10,704
41	14,626	13,789	13,028	12,337	11,705	10,599
42	14,407	13,596	12,858	12,185	11,570	10,490
43	14,185	13,399	12,683	12,029	11,431	10,378
44	13,958	13,199	12,504	11,870	11,288	10,263
45	13,728	12,993	12,322	11,707	11,142	10,144
46	13,493	12,784	12,135	11,540	10,992	10,021
47	13,254	12,571	11,944	11,368	10,837	9,895
48	13,012	12,354	11,748	11,192	10,679	9,765
49	12,764	12,131	11,548	11,012	10,515	9,630
50	12,511	11,904	11,344	10,827	10,348	9,492
51	12,255	11,673	11,135	10,638	10,176	9,349
52	11,994	11,437	10,921	10,443	9,999	9,201
53	11,729	11,195	10,702	10,243	9,817	9,049
54	11,457	10,950	10,478	10,039	9,630	8,891
55	11,183	10,698	10,248	9,829	9,437	8,729
56	10,902	10,443	10,014	9,614	9,239	8,561
57	10,616	10,181	9,773	9,393	9,036	8,387
58	10,325	9,913	9,527	9,166	8,826	8,208
59	10,029	9,640	9,275	8,933	8,611	8,023
60	9,727	9,361	9,017	8,694	8,389	7,831
61	9,419	9,076	8,753	8,449	8,161	7,633
62	9,107	8,786	8,482	8,197	7,926	7,428
63	8,787	8,488	8,205	7,938	7,684	7,216

Age.	3 per Ct.	3½ per Ct.	4 per Ct.	4½ per Ct.	5 per Ct.	6 per Ct.
64	8,462	8,185	7,921	7,672	7,435	6,997
65	8,132	7,875	7,631	7,399	7,179	6,770
66	7,794	7,558	7,333	7,119	6,915	6,535
67	7,450	7,234	7,027	6,831	6,643	6,292
68	7,099	6,902	6,714	6,534	6,362	6,040
69	6,743	6,565	6,394	6,230	6,073	5,779
70	6,378	6,219	6,065	5,918	5,775	5,508
71	6,008	5,865	5,728	5,596	5,468	5,228
72	5,631	5,505	5,383	5,265	5,152	4,937
73	5,246	5,136	5,029	4,926	4,826	4,636
74	4,854	4,759	4,666	4,576	4,489	4,324
75	4,453	4,373	4,293	4,217	4,143	4,000
76	4,046	3,978	3,912	3,847	3,784	3,664
77	3,632	3,575	3,520	3,467	3,415	3,315
78	3,207	3,163	3,111	3,076	3,034	2,953
79	2,776	2,741	2,707	2,673	2,641	2,578
80	2,334	2,309	2,284	2,259	2,235	2,188
81	1,886	1,867	1,850	1,832	1,816	1,783
82	1,429	1,411	1,406	1,394	1,384	1,362
83	0,961	0,955	0,950	0,943	0,937	0,925
84	0,484	0,483	0,481	0,479	0,476	0,472
85	0,000	0,000	0,000	0,000	0,000	0,000

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TABLE II. Showing the Value of an Annuity on the Joint Continuance of Two Lives, according to M. de Moivre's Hypothesis.

Age of the Youngest.	Age of the Eldest.	Value at 3 per Cent.	Value at 4 per Cent.	Value at 5 per Cent.
10	10	15.206	13.342	11.855
	15	14.878	13.093	11.661
	20	14.503	12.808	11.430
	25	14.074	12.480	11.182
	30	13.585	12.102	10.884
	35	13.025	11.665	10.537
	40	12.381	11.156	10.128
	45	11.644	10.564	9.646
	50	10.796	9.871	9.074
	55	9.822	9.059	8.391
15	60	8.704	8.105	7.572
	65	7.417	6.980	6.585
	70	5.936	5.652	5.391
	15	14.574	12.860	11.478
	20	14.225	12.593	11.266
	25	13.822	12.281	11.022
	30	13.359	11.921	10.736
	35	12.824	11.501	10.402
	40	12.207	11.013	10.008
	45	11.496	10.440	9.541
20	50	10.675	9.767	8.985
	55	9.727	8.975	8.318
	60	8.632	8.041	7.515
	65	7.377	6.934	6.544
	70	5.932	5.623	5.364
	20	13.904	12.341	11.067
	25	13.531	12.051	10.840
	30	13.098	11.711	10.565

Age

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Age of the Youngest.	Age of the Elderly.	Value at 3 per Cent.	Value at 4 per Cent.	Value at 5 per Cent.
20	35	12.594	11.314	10.278
	40	12.008	10.847	9.870
	45	11.325	10.297	9.420
	50	10.536	9.648	8.880
	55	9.617	8.879	8.233
	60	8.549	7.967	7.448
	65	7.308	6.882	6.495
25	70	5.868	5.590	5.333
	25	13.192	11.786	10.621
	30	12.794	11.468	10.367
	35	12.333	11.093	10.067
	40	11.770	10.655	9.708
	45	11.130	10.131	9.278
	50	10.374	9.509	8.761
30	55	9.488	8.766	8.134
	60	8.452	7.830	7.371
	65	7.241	6.826	6.440
	70	5.826	5.551	5.294
	30	12.434	11.182	10.133
	35	12.019	10.838	9.854
	40	11.502	10.428	9.514
35	45	10.898	9.936	9.112
	50	10.183	9.345	8.620
	55	9.338	8.634	8.018
	60	8.338	7.779	7.280
	65	7.161	6.748	6.373
	70	5.777	5.505	5.254
	35	11.632	10.530	9.600
40	40	11.175	10.157	9.291
	45	10.622	9.702	8.913
	50	9.955	9.149	8.450
	55	9.156	8.466	7.879
	60	8.202	7.658	7.172
	65	7.266	6.662	6.294
	70	5.718	5.450	5.203
45	40	10.777	9.826	9.014
	45	10.283	9.418	8.671
	50	9.677	8.911	8.244
	55	8.936	8.283	7.710
	60	8.038	7.510	7.039
	65	6.951	6.556	6.198
	70	5.646	5.383	5.141
50	45	9.863	9.063	8.370
	50	9.331	8.619	7.987
	55	8.662	8.044	7.500
	60	7.831	7.332	6.875
	65	6.807	6.435	6.080
	70	5.556	5.300	5.063
	50	8.892	8.235	7.660
55	55	8.312	7.738	7.230
	60	7.568	7.091	6.664
	65	6.623	6.258	5.926
	70	5.442	5.193	4.964
	55	7.849	7.332	6.873
	60	7.220	6.781	6.386
	65	6.379	6.036	5.724
60	70	5.201	5.053	4.833
	60	6.737	6.351	6.001
	65	6.043	5.730	5.444
	70	5.081	4.858	4.653
	65	5.547	5.277	5.031
	70	4.773	4.571	4.385
	70	4.270	4.104	3.952

TABLE III. Showing the Values of Annuities on Single Lives,
among Males and Females, according to the Probabilities of
the Duration of Life in the Kingdom of Sweden.

Ages.	MALES.		FEMALES.		Lives in general.	
	4 per Ct.	5 per Ct.	4 per Ct.	5 per Ct.	4 per Ct.	5 per Ct.
1	16.503	14.051	16.820	14.271	16.661	14.161
2	17.355	14.778	17.719	15.034	17.537	14.906
3	17.935	15.279	18.344	15.571	18.139	15.425
4	18.328	15.624	18.780	15.951	18.554	15.787
5	18.503	15.786	18.927	16.088	18.715	15.937
6	18.622	15.901	19.045	16.203	18.833	16.052
7	18.693	15.977	19.131	16.291	18.912	16.134
8	18.725	16.021	19.162	16.335	18.943	16.178
9	18.715	16.030	19.151	16.343	18.933	16.186
10	18.674	16.014	19.109	16.325	18.891	16.169
11	18.600	15.970	19.041	16.286	18.820	16.128
12	18.491	15.896	18.952	16.229	18.721	16.062
13	18.378	15.819	18.840	16.153	18.609	15.986
14	18.246	15.724	18.707	16.059	18.476	15.891
15	18.105	15.624	18.568	15.960	18.336	15.792
16	17.958	15.517	18.424	15.856	18.191	15.686
17	17.803	15.404	18.290	15.761	18.046	15.582
18	17.643	15.285	18.151	15.662	17.897	15.473
19	17.492	15.175	18.013	15.563	17.752	15.369
20	17.335	15.059	17.872	15.462	17.603	15.260
21	17.192	14.955	17.725	15.356	17.458	15.155
22	17.042	14.846	17.573	15.245	17.307	15.045
23	16.887	14.732	17.414	15.129	17.150	14.930
24	16.742	14.627	17.252	15.009	16.997	14.818
25	16.592	14.517	17.087	14.886	16.839	14.701
26	16.436	14.402	16.915	14.757	16.675	14.579
27	16.274	14.282	16.751	14.636	16.512	14.459
28	16.105	14.156	16.588	14.515	16.346	14.335
29	15.930	14.024	16.427	14.396	16.178	14.210
30	15.751	13.889	16.261	14.272	16.006	14.080
31	15.575	13.756	16.104	14.156	15.839	13.956
32	15.395	13.619	15.941	14.035	15.668	13.827
33	15.208	13.477	15.787	13.923	15.497	13.700
34	15.014	13.327	15.629	13.806	15.321	13.566
35	14.812	13.170	15.465	13.684	15.138	13.427
36	14.601	13.006	15.278	13.542	14.939	13.274
37	14.382	12.833	15.070	13.382	14.726	13.107
38	14.154	12.652	14.854	13.213	14.504	12.932
39	13.916	12.462	14.629	13.036	14.272	12.749
40	13.668	12.261	14.401	12.856	14.034	12.558
41	13.426	12.065	14.185	12.687	13.805	12.376
42	13.196	11.880	13.994	12.538	13.595	12.209
43	12.984	11.710	13.798	12.387	13.391	12.048
44	12.763	11.532	13.596	12.229	13.179	11.880
45	12.535	11.347	13.383	12.061	12.959	11.704
46	12.297	11.153	13.151	11.876	12.724	11.514
47	12.051	10.951	12.894	11.668	12.472	11.309
48	11.795	10.738	12.620	11.443	12.217	11.090
49	11.528	10.516	12.333	11.205	11.930	10.860
50	11.267	10.298	12.049	10.970	11.658	10.634
51	11.030	10.100	11.769	10.737	11.399	10.418
52	10.785	9.895	11.492	10.507	11.138	10.201
53	10.531	9.682	11.220	10.280	10.875	9.981
54	10.269	9.460	10.937	10.042	10.603	9.751
55	9.998	9.229	10.642	9.792	10.320	9.500
56	9.717	8.988	10.334	9.529	10.025	9.258
57	9.425	8.736	10.012	9.253	9.718	8.994
58	9.140	8.489	9.692	8.976	9.416	8.732
59	8.845	8.232	9.358	8.687	9.101	8.458
60	8.540	7.963	9.039	8.406	8.789	8.184
61	8.241	7.700	8.739	8.144	8.490	7.922

Survivor-
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Ages.	MALES.		FEMALES.		Lives in general.	
	4 per Ct.	5 per Ct.	4 per Ct.	5 per Ct.	4 per Ct.	5 per Ct.
62	7.950	7.442	8.453	7.895	8.201	7.668
63	7.669	7.193	8.166	7.643	7.917	7.418
64	7.382	6.938	7.870	7.382	7.626	7.160
65	7.090	6.676	7.566	7.111	7.328	6.893
66	6.792	6.408	7.252	6.831	7.027	6.619
67	6.489	6.134	6.930	6.541	6.709	6.337
68	6.201	5.872	6.596	6.239	6.398	6.055
69	5.933	5.628	6.253	5.926	6.093	5.777
70	5.670	5.389	5.897	5.599	5.783	5.494
71	5.418	5.158	5.564	5.293	5.491	5.225
72	5.180	4.940	5.261	5.013	5.220	4.976
73	4.940	4.719	4.998	4.770	4.969	4.744
74	4.724	4.521	4.792	4.581	4.758	4.551
75	4.487	4.302	4.582	4.388	4.534	4.345
76	4.253	4.084	4.367	4.189	4.310	4.136
77	4.024	3.871	4.145	3.983	4.084	3.927
78	3.768	3.631	3.913	3.767	3.840	3.699
79	3.512	3.390	3.668	3.536	3.590	3.463
80	3.260	3.152	3.402	3.285	3.331	3.218
81	3.017	2.921	3.145	3.041	3.081	2.981
82	2.792	2.706	2.905	2.812	2.848	2.759
83	2.600	2.523	2.699	2.615	2.649	2.569
84	2.473	2.403	2.559	2.480	2.516	2.441
85	2.371	2.306	2.552	2.476	2.461	2.391
86	2.281	2.222	2.518	2.446	2.399	2.334
87	2.154	2.103	2.431	2.365	2.292	2.338
88	1.955	1.912	2.294	2.236	2.124	2.074
89	1.698	1.664	2.108	2.059	1.903	1.861
90	1.417	1.392	1.873	1.833	1.645	1.612
91	1.154	1.136	1.628	1.596	1.391	1.366
92	0.835	0.824	1.349	1.325	1.092	1.074
93	0.477	0.471	1.071	1.054	0.774	0.762
94	0.240	0.238	0.799	0.788	0.519	0.513
95	0.000	0.000	0.544	0.537		
96	0.000	0.000	0.320	0.317		

TABLE IV. Showing the Value of Annuities on Two Joint Lives, according to the Probabilities of the Duration of Human Life among Males and Females collectively, reckoning interest at 4 per cent.

Interest 4 per cent.

Difference of 0, 6, 12, and 18 years.

Ages.	Values.	Ages.	Values.	Ages.	Values.	Ages.	Values.
1-1	12.252	1-7	13.989	1-13	13.894	1-19	13.389
2-2	13.583	2-8	14.780	2-14	14.557	2-20	14.008
3-3	14.558	3-9	15.323	3-15	14.988	3-21	14.417
4-4	15.267	4-10	15.685	4-16	15.259	4-22	14.671
5-5	15.577	5-11	15.817	5-17	15.326	5-23	14.725
6-6	15.820	6-12	15.887	6-18	15.354	6-24	14.740
7-7	16.003	7-13	15.914	7-19	15.351	7-25	14.727
8-8	16.109	8-14	15.888	8-20	15.310	8-26	14.673
9-9	16.152	9-15	15.824	9-21	15.244	9-27	14.590
10-10	16.141	10-16	15.729	10-22	15.149	10-28	14.484
11-11	16.087	11-17	15.617	11-23	15.033	11-29	14.357
12-12	15.982	12-18	15.477	12-24	14.889	12-30	14.202
13-13	15.855	13-19	15.327	13-25	14.736	13-31	14.045
14-14	15.701	14-20	15.164	14-26	14.566	14-32	13.874
15-15	15.535	15-21	15.001	15-27	14.392	15-33	13.700
16-16	15.361	16-22	14.832	16-28	14.216	16-34	13.520
17-17	15.196	17-23	14.665	17-29	14.042	17-35	13.340
18-18	15.023	18-24	14.491	18-30	13.860	18-36	13.141
19-19	14.854	19-25	14.320	19-31	13.687	19-37	12.934

Interest 4 per cent.

Ages.	Values.	Ages.	Values.	Ages.	Values.	Ages.	Values.
20-20	14.682	20-26	14.144	20-32	13.512	20-38	12.720
21-21	14.525	21-27	13.976	21-33	13.345	21-39	12.505
22-22	14.360	22-28	13.807	22-34	13.173	22-40	12.286
23-23	14.194	23-29	13.635	23-35	12.997	23-41	12.073
24-24	14.020	24-30	13.455	24-36	12.801	24-42	11.873
25-25	13.849	25-31	13.284	25-37	12.599	25-43	11.683
26-26	13.671	26-32	13.108	26-38	12.387	26-44	11.485
27-27	13.495	27-33	12.935	27-39	12.170	27-45	11.284
28-28	13.323	28-34	12.763	28-40	11.953	28-46	11.072
29-29	13.148	29-35	12.586	29-41	11.742	29-47	10.847
30-30	12.965	30-36	12.390	30-42	11.543	30-48	10.606
31-31	12.793	31-37	12.192	31-43	11.359	31-49	10.363
32-32	12.624	32-38	11.988	32-44	11.170	32-50	10.128
33-33	12.456	33-39	11.779	33-45	10.978	33-51	9.905
34-34	12.286	34-40	11.568	34-46	10.775	34-52	9.679
35-35	12.109	35-41	11.361	35-47	10.557	35-53	9.452
36-36	11.904	36-42	11.156	36-48	10.314	36-54	9.207
37-37	11.683	37-43	10.953	37-49	10.059	37-55	8.951
38-38	11.452	38-44	10.741	38-50	9.805	38-56	8.683
39-39	11.209	39-45	10.519	39-51	9.556	39-57	8.404
40-40	10.964	40-46	10.286	40-52	9.308	40-58	8.124
41-41	10.732	41-47	10.049	41-53	9.066	41-59	7.839
42-42	10.531	42-48	9.813	42-54	8.830	42-60	7.569
43-43	10.346	43-49	9.581	43-55	8.597	43-61	7.318
44-44	10.154	44-50	9.351	44-56	8.354	44-62	7.075
45-45	9.954	45-51	9.129	45-57	8.101	45-63	6.836
46-46	9.736	46-52	8.897	46-58	7.841	46-64	6.586
47-47	9.497	47-53	8.658	47-59	7.563	47-65	6.323
48-48	9.236	48-54	8.402	48-60	7.281	48-66	6.048
49-49	8.966	49-55	8.139	49-61	7.006	49-67	5.764
50-50	8.707	50-56	7.874	50-62	6.740	50-68	5.487
51-51	8.469	51-57	7.613	51-63	6.505	51-69	5.221
52-52	8.230	52-58	7.351	52-64	6.256	52-70	4.953
53-53	7.994	53-59	7.083	53-65	6.004	53-71	4.694
54-54	7.748	54-60	6.814	54-66	5.743	54-72	4.453
55-55	7.495	55-61	6.553	55-67	5.474	55-73	4.231
56-56	7.229	56-62	6.299	56-68	5.204	56-74	4.043
57-57	6.924	57-63	6.045	57-69	4.936	57-75	3.844
58-58	6.678	58-64	5.788	58-70	4.664	58-76	3.637
59-59	6.388	59-65	5.519	59-71	4.395	59-77	3.430
60-60	6.104	60-66	5.249	60-72	4.149	60-78	3.210
61-61	5.844	61-67	4.984	61-73	3.927	61-79	2.974
62-62	5.600	62-68	4.720	62-74	3.747	62-80	2.744
63-63	5.367	63-69	4.482	63-75	3.563	63-81	2.557
64-64	5.128	64-70	4.231	64-76	3.370	64-82	2.396
65-65	4.881	65-71	3.982	65-77	3.180	65-83	2.252
66-66	4.626	66-72	3.750	66-78	2.974	66-84	2.123
67-67	4.362	67-73	3.527	67-79	2.743	67-85	2.010
68-68	4.103	68-74	3.340	68-80	2.514	68-86	1.910
69-69	3.851	69-75	3.147	69-81	2.324	69-87	1.798
70-70	3.593	70-76	2.946	70-82	2.153	70-88	1.661
71-71	3.345	71-77	2.752	71-83	2.004	71-89	1.464
72-72	3.128	72-78	2.558	72-84	1.875	72-90	1.189
73-73	2.935	73-79	2.355	73-85	1.768	73-91	0.937
74-74	2.797	74-80	2.172	74-86	1.692	74-92	0.708
75-75	2.648	75-81	2.017	75-87	1.605	75-93	0.575
76-76	2.490	76-82	1.877	76-88	1.497	76-94	0.481
77-77	2.340	77-83	1.756	77-89	1.339	77-95	0.421
78-78	2.170	78-84	1.639	78-90	1.097		
79-79	1.967	79-85	1.524	79-91	0.863		
80-80	1.758	80-86	1.416	80-92	0.638		
81-81	1.600	81-87	1.320	81-93	0.511		
82-82	1.472	82-88	1.225	82-94	0.427		
83-83	1.364	83-89	1.094	83-95	0.379		
84-84	1.276	84-90	0.902				

Survivor-
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Interest

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Interest 4 per cent.

Ages.	Values.	Ages.	Values.	Ages.	Values.	Ages.	Values.
85-85	1.212	85-91	0.725				
86-86	1.172	86-92	0.556				
87-87	1.127	87-93	0.459				
88-88	1.071	88-94	0.396				
89-89	0.940	89-95	0.364				
90-90	0.718						
91-91	0.516						
92-92	0.326						
93-93	0.236						
94-94	0.190						
95-95	0.024						

TABLE V. Showing the Values of two Joint Lives, according to the Probabilities of the Duration of Human Life among Males and Females collectively.

Interest 4 per cent.

Difference of age 24, 30, 36, and 42 years.

Ages.	Values.	Ages.	Values.	Ages.	Values.	Ages.	Values.
1-25	12.832	1-31	12.196	1-37	11.465	1-43	10.546
2-26	13.409	2-32	12.730	2-38	11.913	2-44	10.946
3-27	13.778	3-33	13.006	3-39	12.164	3-45	11.168
4-28	14.003	4-34	13.264	4-40	12.284	4-46	11.260
5-29	14.037	5-35	13.277	5-41	12.242	5-47	11.183
6-30	14.033	6-36	13.242	6-42	12.185	6-48	11.064
7-31	14.006	7-37	13.170	7-43	12.112	7-49	10.915
8-32	13.944	8-38	13.059	8-44	12.004	8-50	10.743
9-33	13.855	9-39	12.913	9-45	11.865	9-51	10.560
10-34	13.741	10-40	12.743	10-46	11.694	10-52	10.357
11-35	13.604	11-41	12.563	11-47	11.493	11-53	10.140
12-36	13.428	12-42	12.379	12-48	11.259	12-54	9.898
13-37	13.234	13-43	12.196	13-49	11.011	13-55	9.644
14-38	13.023	14-44	11.997	14-50	10.759	14-56	9.371
15-39	12.798	15-45	11.787	15-51	10.510	15-57	9.087
16-40	12.570	16-46	11.562	16-52	10.264	16-58	8.799
17-41	12.351	17-47	11.328	17-53	10.018	17-59	8.503
18-42	12.146	18-48	11.076	18-54	9.761	18-60	8.208
19-43	11.951	19-49	10.819	19-55	9.500	19-61	7.928
20-44	11.751	20-50	10.567	20-56	9.228	20-62	7.658
21-45	11.550	21-51	10.332	21-57	8.953	21-63	7.396
22-46	11.335	22-52	10.092	22-58	8.675	22-64	7.127
23-47	11.107	23-53	9.852	23-59	8.385	23-65	6.851
24-48	10.862	24-54	9.602	24-60	8.097	24-66	6.566
25-49	10.612	25-55	9.347	25-61	7.823	25-67	6.275
26-50	10.364	26-56	9.080	26-62	7.557	26-68	5.986
27-51	10.130	27-57	8.807	27-63	7.297	27-69	5.702
28-52	9.894	28-58	8.534	28-64	7.032	28-70	5.415
29-53	9.659	29-59	8.250	29-65	6.761	29-71	5.136
30-54	9.413	30-60	7.967	30-66	6.481	30-72	4.881
31-55	9.167	31-61	7.702	31-67	6.197	31-73	4.646
32-56	8.912	32-62	7.446	32-68	5.917	32-74	4.453
33-57	8.651	33-63	7.196	33-69	5.642	33-75	4.251
34-58	8.389	34-64	6.942	34-70	5.364	34-76	4.040
35-59	8.114	35-65	6.679	35-71	5.093	35-77	3.833
36-60	7.833	36-66	6.402	36-72	4.840	36-78	3.605
37-61	7.561	37-67	6.115	37-73	4.603	37-79	3.352
38-62	7.296	38-68	5.828	38-74	4.405	38-80	3.098
39-63	7.033	39-69	5.543	39-75	4.195	39-81	2.889
40-64	6.763	40-70	5.254	40-76	3.975	40-82	2.710
41-65	6.492	41-71	4.977	41-77	3.762	41-83	2.553
42-66	6.225	42-72	4.730	42-78	3.539	42-84	2.418
43-67	5.957	43-73	4.507	43-79	3.295	43-85	2.305
44-68	5.689	44-74	4.322	44-80	3.052	44-86	2.203

Interest 4 per cent.

A. e.	values.	Ages.	Values.	Ages.	Values.	Ages.	Values.
45-69	5.426	45-75	4.128	45-81	2.854	45-87	2.083
46-70	5.153	46-76	3.921	46-82	2.684	46-88	1.933
47-71	4.884	47-77	3.715	47-83	2.533	47-89	1.708
48-72	4.633	48-78	3.489	48-84	2.396	48-90	1.385
49-73	4.398	49-79	3.238	49-85	2.277	49-91	1.090
50-74	4.205	50-80	2.990	50-86	2.171	50-92	0.818
51-75	4.008	51-81	2.792	51-87	2.050	51-93	0.662
52-76	3.803	52-82	2.623	52-88	1.901	52-94	0.551
53-77	3.605	53-83	2.475	53-89	1.681	53-95	0.468
54-78	3.389	54-84	2.344	54-90	1.366		
55-79	3.150	55-85	2.232	55-91	1.078		
56-80	2.909	56-86	2.130	56-92	0.810		
57-81	2.710	57-87	2.010	57-93	0.655		
58-82	2.539	58-88	1.864	58-94	0.546		
59-83	2.385	59-89	1.644	59-95	0.464		
60-84	2.248	60-90	1.333				
61-85	2.135	61-91	1.050				
62-86	2.037	62-92	0.789				
63-87	1.916	63-93	0.639				
64-88	1.790	64-94	0.533				
65-89	1.585	65-95	0.456				
66-90	1.290						
67-91	1.017						
68-92	0.764						
69-93	0.617						
70-94	0.514						
71-95	0.411						

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The values of joint lives in these tables have been computed for only one rate of interest; and of single lives in Table III. for only two rates of interest. The following rules will show, that it would be a needless labour to compute these values (in strict conformity to the observations) for any other rates of interest.

ACCOUNT of a method of deducing, from the correct values (according to any observations) of any single or joint lives at one rate of interest, the same values at other rates of interest.

PRELIMINARY PROBLEMS.

PROB. I. The expectation given of a single life by any table of observations, to find its value, supposing the decrements of life equal, at any given rate of interest.

Solution. Find the value of an annuity certain for a number of years equal to twice the expectation. Multiply this value by the perpetuity increased by unity, and divide the product by twice the expectation: The quotient subtracted from the perpetuity will be the value required.

Example. The expectation of a male life aged 10, by the Sweden observations, is 43.94. Twice this expectation is 87.88. The value of an annuity certain for 87.88 years is (reckoning interest at 4 per cent.) 24.200. The product of 24.200 into 26 (the perpetuity increased by unity) is 629.2, which, divided by 87.88, gives 7.159. And this quotient subtracted from 25 (the perpetuity) gives 17.84 years purchase, the value of a life aged ten, deduced from the expectation of life at that age, according to the Sweden observations. (See the Tables in Dr Price on Reversions, vol. ii.).

PROB. II. Having the expectations given of any two lives by any table of observations, to deduce from thence the value of the joint lives at any rate of interest, supposing an equal decrement of life.

Solution. Find the difference between twice the expectation

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tation of the youngest life and twice the expectation of the oldest life increased by unity and twice the perpetuity. Multiply this difference by the value of an annuity certain for a time equal to twice the expectation of the oldest life; and by twice the same expectation divide the product, reserving the quotient.

From twice the perpetuity subtract the reserved quotient, and multiply the remainder by the perpetuity increased by unity. This last product divided by twice the expectation of the youngest life, and then subtracted from the perpetuity, will be the required value.

When twice the expectation of the youngest life is greater than twice the expectation of the oldest life increased by unity and twice the perpetuity, the reserved quotient, instead of being subtracted from twice the perpetuity, must be added to it, and the sum, not the difference, multiplied by the perpetuity increased by unity.

Example. Let the joint lives proposed be a female life aged 10, and a male life aged 15; and let the table of observations be the Sweden table for lives in general, and the rate of interest 4 per cent. Twice the expectations of the two lives are 90.14 and 83.28.

Twice the expectation of the oldest life, increased by unity, and twice the perpetuity, is 134.28, which lessens by 90.14 (twice the expectation of the youngest life), leaves 44.14 for the reserved remainder. This remainder multiplied by 24.045 (the value of an annuity certain for 83.28 years), and the product divided by 83.28 (twice the expectation of the oldest life), gives 12.744, the quotient to be reserved; which subtracted from double the perpetuity, and the remainder (or 37.255) multiplied by the perpetuity increased by unity (or by 26) gives 968.630, which divided by 90.14 (twice the expectation of the youngest life) and the quotient subtracted from the perpetuity, we have 14.254 for the required value.

The value of an annuity certain, when the number of years is a whole number with a fraction added (as will be commonly the case) may be best computed in the following manner. In this example the number of years is 83.28. The value of an annuity certain for 83 years is 24.035. The same value for 84 years is 24.072. The difference between these two values is 0.37; which difference multiplied by .28 (the fractional part of the number of years), and the product (.0103) added to the least of the two values, will give 24.045 the value for 83.28 years.

General Rule. Call the correct value (supposed to be computed for any rate of interest) the first value. Call the value deduced (by the preceding problems) from the expectations at the same rate of interest, the second value. Call the value deduced from the expectations for any other rate of interest the third value.

Then the difference between the first and second values added to or subtracted from the third value, just as the first is greater or less than the second, will be the value at the rate of interest for which the third value has been deduced from the expectations.

The following examples will make this perfectly plain.

Example I. In the two last tables the correct values are given of two joint lives among mankind at large, without distinguishing between males and females, according to the Sweden observations, reckoning interest at 4 per cent. Let it be required to find from these values the values at 3 per cent. and let the ages of the joint lives be supposed 10 and 10.

The correct value by Table IV. (reckoning interest at 4 per cent.) is 16.141. The expectation of a life aged 10 is 45.07. The value deduced from this expectation at 4 per cent. by Prob. II. is 14.539. The value deduced by the

same problem from the same expectation at 3 per cent. is 16.808. The difference between the first and second values is 1.602, which, added to the third value (the first being greater than the second), makes 18.410, the value required.

Example II. Let the value be required of a single male life aged 10, at 3 per cent. interest, from the correct value at 4 per cent. according to the Sweden observations.

First, or correct value at 4 per cent. (by Table III.) is 18.674. The expectation of a male life aged 10 is 43.94.

The second value (or the value deduced from this expectation by Prob. I.) is 17.838.

The third value (or the value deduced from the same expectation at 3 per cent.) is 21.277.

The difference between the first and second is .836; which (since the first is greater than the second) must be added to the third; and the sum (that is, 22.113) will be the value required.

The third value at 5 per cent. is 15.286; and the difference added to 15.286 makes 16.122 the value of a male life aged 10 at 5 per cent. according to the Sweden observations. The exact value at 5 per cent. is (by Table III.) 16.014.

Again: The difference between 16.014 (the correct value at 5 per cent.), and 15.286 (the value at the same interest deduced from the expectation), is .728; which, added (because the first value is greater than the second) to 13.335 (the value deduced at 6 per cent. from the expectation) gives 14.063, the value of the same life, reckoning interest at 6 per cent.

These deductions, in the case of single lives particularly, are so easy, and give the true values so nearly, that it will be scarcely ever necessary to calculate the exact values (according to any given observations) for more than one rate of interest.

If, for instance, the correct values are computed at 4 per cent. according to any observations, the values at 3, $3\frac{1}{2}$, $4\frac{1}{2}$, 5, 6, 7, or 8 per cent. may be deduced from them by the preceding rules as occasion may require, without much labour or any danger of considerable errors. The values thus deduced will seldom differ from the true values so much as a tenth of a year's purchase. They will not generally differ more than a 20th or 30th of a year's purchase. In joint lives they will differ less than in single lives, and they will come equally near to one another whatever the rates of interest are.

The preceding tables furnish the means of determining the exact differences between the values of annuities, as they are made to depend on the survivorship of any male or female lives; which hitherto has been a desideratum of considerable consequence in the doctrine of life-annuities. What has made this of consequence is chiefly the multitude of societies lately established in this and foreign countries for providing annuities for widows. The general rule for calculating from these tables the value of such annuities is the following.

Rule. "Find in Table III. the value of a female life at the age of the wife. From this value subtract the value in Table IV. of the joint continuance of two lives at the ages of the husband and wife. The remainder will be the value in a single present payment of an annuity for the life of the wife, should she be left a widow. And this last value divided by the value of the joint lives increased by unity, will be the value of the same annuity in annual payments during the joint lives, and to commence immediately."

Example. Let the age of the wife be 24, and of the husband 30. The value in Table III. (reckoning interest at 4 per cent.) of a female life aged 24, is 17.252. The value in Table IV. of two joint lives aged 24 and 30, is 13.455, which subtracted from 17.252 leaves 3.797, the value

Surya,
Sus.

value in a single present payment of an annuity of L. 1 for the life of the wife after the husband; that is, for the life of the widow. The annuity, therefore, being supposed L. 20, its value in a single payment is 20 multiplied by 3.797, that is, L. 75.94. And this last value divided by 14.455 (that is, by the value of the joint lives increased by unity), gives 5.25, the value in annual payments beginning immediately, and to be continued during the joint lives of an annuity of L. 20 to a wife aged 24 for her life, after her husband aged 30.

SURYA, the orb of the sun personified and adored by a sect of Hindoos as a god. He seems to be the same divinity with the Phœbus of Greece and Rome; and the sect who pay him particular adoration are called *Sauras*. Their poets and painters describe his car as drawn by seven green horses, preceded by Arun, or the *Dawn*, who acts as his charioteer, and followed by thousands of genii worshipping him and modulating his praises. He has a multitude of names, and among them twelve epithets or titles, which denote his distinct powers in each of the twelve months; and he is believed to have descended frequently from his car in a human shape, and to have left a race on earth, who are equally renowned in the Indian stories with the Heliadae of Greece: it is very singular, that his two sons called *Aswinau* or *Aswinicumarau*, in the dual, should be considered as twin-brothers, and painted like Castor and Pollux; but they have each the character of Æsculapius among the gods, and are believed to have been born of a nymph, who, in the form of a mare, was impregnated with sun-beams.

SUS, the Hog, in zoology, a genus of quadrupeds belonging to the class of *mammalia* and order of *bellua*. There are four cutting teeth in the upper jaw, whose points converge; and, for the most part, six in the lower jaw, which stand forwards: There are two tusks in each jaw, those in the upper jaw being short, while those of the under jaw are long, and extend out of the mouth. The snout is prominent, moveable, and has the appearance of having been cut off, or truncated. The feet are armed with divided or cloven hoofs. There are six species; the *scrofa*, *æthiopicus*, *tajassu*, *babyrussa*, *porcus*, and *africanus*. The most remarkable are,

1. The *scrofa*, or common hog, having the body covered with bristles; two large teeth above and below. In a wild state, of a dark brindled colour, and beneath the bristles is a soft short hair; the ears short, and a little rounded. TAME: the ears long, sharp-pointed, and slouching; the colour generally white, sometimes mixed with other colours. In a tame state it is universal; except in the frigid zones, and in Kamtschatka, where the cold is very severe. Since its introduction into America by the Europeans, it abounds to excess in the hot and temperate parts. It is found wild in most parts of Europe. In the forests of South America there are vast droves, which derive their origin from the European kind relapsed into a state of nature; and are what Mr Bancroft, in his History of Guiana, describes as a particular species by the name of *Warree*. They cannot bear excessive cold; inhabit wooded countries; and are very swift. In America they are useful by clearing the country of rattle-snakes, which they devour without danger.

Of all quadrupeds, the hog is the most rude and brutal. The imperfections of his form seem to have an influence on his nature and dispositions. All his habits are gross; all his appetites are impure; all his sensations are confined to a furious lust, and a brutal gluttony. He devours indiscriminately every thing that comes in his way, even his own progeny the moment after their birth. This voraciousness seems to proceed from the perpetual cravings of his stomach, which is of an immoderate size; and the grossness of his

appetites, it is probable, arises from the bluntness of his senses of taste and of feeling. The rudeness of the hair, the hardness of the skin, and the thickness of the fat, render these animals less sensible to blows. Mice have been known to lodge upon a hog's back, and to eat his skin and fat, without his showing any marks of sensibility. The other senses of the hog are very good. It is well known to the hunters that the wild boar hears and smells at a great distance; for, in order to surprise him, they are obliged to watch him in silence during the night, and to place themselves opposite to the wind, that he may not perceive the smell, which never fails to make him turn back.

But the hog, though the most impure and filthy of all quadrupeds, is yet useful by the very sordidness of its manners; this alone devouring what is the refuse of all others, and contributing not only to remove what would be a nuisance to the human race, but also converting the most nauseous offals into the richest nutriment: for this reason its stomach is capacious, and its gluttony excessive: not that its palate is insensible to the difference of eatables; for where it finds variety, it will reject the worst with as distinguishing a taste as other quadrupeds.

The parts of this animal are finely adapted to its way of life. As its method of feeding is by turning up the earth with its nose for roots of different kinds, so nature has given it a more prone form than other animals; a strong brawny neck; eyes small, and placed high in the head; a long snout, nose callous and tough, and a quick sense of smelling to trace out its food. Its intestines have a strong resemblance to those of the human species. The external form of its body is very unwieldy; yet, by the strength of its tendons, the wild boar (which is only a variety of the common kind) is enabled to fly from the hunters with amazing agility: the back-toe on the feet of this animal prevents its slipping while it descends declivities, and must be of singular use when pursued. Yet, notwithstanding its powers of motion, it is by nature stupid, inactive, and drowsy; much inclined to increase in fat, which is disposed in a different manner from that of other animals, and forms a regular coat over the whole body. It is restless at a change of weather, and in certain high winds is so agitated as to run violently, screaming horribly at the same time: it is fond of wallowing in the dirt, either to cool its surfeited body, or to destroy the lice, ticks, and other insects with which it is infested. Its diseases generally arise from foul feeding and intemperance; measles, imposthumes, and scrophulous complaints, are reckoned among them. These are best prevented by keeping the animals, as the ancients strongly recommended, very clean in their sties; allowing them air, exercise, and a sufficiency of water. Linnæus observes, that its flesh is wholesome food for athletic constitutions, or those that use much exercise; but bad for such as lead a sedentary life: it is, however, of most universal use; and furnishes numberless materials for epicurism.

The boar, or male of these creatures, is chosen with great care, when intended for the propagation of his species; and is thus employed from the age of two to five years, and then either sold or fattened. The males not allotted to this use are castrated, sometimes at the age of six weeks, and sometimes when they are six months old; and then fed to a great size either for sale or for the use of the family. Sows are kept for breed generally from one year old to seven, and are then spayed and fattened. They have commonly more grease on their intestines than hogs, these being fattest on their backs.

As to the age of these animals, it is said that the life of the wild boar may be extended to twenty-five or thirty years.

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searches,
vol. i. p.
262 and
263.Gmelin's
Animal
Kingdom, by
Kerr.Sis.
Buffon's
Natural
History,
vol. iii.

Sus.

Aristotle says, that hogs in general live twenty years; and adds, that both males and females are fertile till they arrive at the age of fifteen. They can engender at the age of nine or twelve months; but it is better to restrain them till they be eighteen months or two years. The first litter of the sow is not numerous; and, when only one year old, her pigs are weak, and even imperfect. She may be said to be in season at all times. Though full, she solicits the approach of the male. This may be regarded as an excess among animals; for almost every other species refuse the male after conception. The ardour of the sow, though almost perpetual, is however marked by paroxysms and immoderate movements, which always terminate by her wallowing in the mire. She, at the same time, emits a thick whitish fluid. She goes four months with young; brings forth in the beginning of the fifth; and soon afterwards solicits the male, is impregnated a second time, and of course brings forth twice a-year. The wild sow, which every way resembles the domestic kind, produces only once a-year. This difference in fertility is probably owing to want of nourishment, and the necessity of suckling her pigs much longer than the domestic sow, which is never allowed to nurse her young above fifteen days or three weeks. Only eight or nine of the litter are kept longer; the rest are sold. In fifteen days, pigs are excellent food.

As these creatures, though exceedingly voracious, will feed almost on any thing, they are bred and kept everywhere, and are quickly and cheaply fatted. In miry and in marshy grounds (from which they are not averse) they devour worms, frogs, fern, rush, and sedge roots. In drier and in woody countries, they feed on hips, haws, sloes, crabs, mast, chefnuts, acorns, &c. and on this food they will grow fleshy and fat. They are a kind of natural scavengers, will thrive on the trash of an orchard, the outcasts of the kitchen, the sweepings of barns and granaries, the offals of a market, and most richly on the refuse of a dairy. If near the sea, they will search the shores for shell-fish; in the fields, they eat grass; and in cities and large towns they are kept in great numbers, and supported chiefly by grains. It is evident that the facility of feeding them everywhere at a small expence, is a national benefit, more especially in a country where the people are accustomed to eat flesh daily, and could not perhaps perform their daily labour if they did not. It is no less observable, that notwithstanding this facility of feeding, and the multitudes of swine maintained, they seldom fail of coming to a good market. In no part of Europe is the management of these creatures better understood than in Britain. The time of farrowing is adjusted to the nature of the farm, the food it can supply; and the number of pigs sold and kept are in like manner adjusted. New kinds of food, more wholesome and nutritive than what were used formerly, have been introduced, such as turnips, carrots, clover, &c. They are in most places regularly managed and closely attended. Tusser, many years since, affirmed from his own experience, that a sow might bring as much profit as a cow. In some counties, it is said, a sow dependent on a dairy hath produced, all expences deducted, about 10*l.* in the space of a year. It may be some satisfaction to the reader to know, that, on a nice calculation, the annual profits of a sow in France are found to be between 50 and 60 *livres*.—In Britain, these animals in different counties are of very different sizes. In Leicestershire, Northamptonshire, and Pembrokehire, they are very large. In Hampshire, Wiltshire, and wherever they can run in the woods, and feed on mast and acorns, their flesh is firmer and better. The Chinese swine are common with us: they are smaller, blacker, and their legs shorter than ours: so that,

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when fat, their bellies literally touch the ground. They thrive exceedingly well with us, are very prolific, and their flesh very fine and well-tasted.

In considering the advantages derived from these creatures, it is to be observed, that the flesh of all their different kinds, and at all ages, is looked upon as a very substantial and agreeable aliment; and of course, in their proper seasons, the different sorts of provisions thus supplied are all of them very saleable. The wild boar was esteemed a prime delicacy amongst the Romans, and the flesh of the tame was much more in favour with our ancestors than with us; though BRAWN has still many admirers, is made in the greatest perfection, and considered as a rarity peculiar to this country. Pork, though it might be wisely prohibited in some warm countries, is found by experience equally nutritive and salutary here. As such it furnishes a very large proportion of that food which is vended in our markets. It takes salt better, and keeps longer, than the flesh of any other animal; and the consumption of it is prodigious when pickled or salted, more especially in our foreign garrisons and in the sea-service. Our bacon is differently cured, so as to render it acceptable to all palates; and our hams are not at all inferior to those of other countries. Fresh pork sells nearly as dear as beef; the lard brings double or triple the price; the blood, the intestines, the feet, and the tongue, are all prepared as food. The fat of the intestines and web, which differs from common lard, is employed for greasing axles of wheels, and for many other purposes. Sieves are made of the skin; and brushes, pencils, &c. of the bristles. The dung is reputed next in value to that of sheep. Mr Worlidge * proposes that swine should be turned into a close well-paled, and planted with greens, pulse, and roots, on which they may feed, and by their trampling and their dung raise a great quantity of excellent soil. Mr Mortimer † assures us that some, on poor light shallow land in Staffordshire, sow a small white pea, which they never reap, but turn in so many hogs to eat them as they think they will fat; and there they lie day and night, and their dung will so enrich the land, that it will bring a good sword upon it, and will graze many years afterwards. Our old husbandmen had an ill opinion of this dung, as supposing it bred weeds, but it will probably not obtain much credit at present. In some places they wash with hogs dung for want of soap; which answers tolerably well, if the linen hangs long enough in the air to become thoroughly sweet.

The wild boar was formerly a native of our country, as appears from the laws of Hoeldda, who permitted his grand huntsman to chase that animal from the middle of November to the beginning of December. William the Conqueror punished with the loss of their eyes any that were convicted of killing the wild boar, the stag, or the roebuck; and Fitz-Stephen tells us, that the vast forest that in his time grew on the north side of London, was the retreat of stags, fallow-deer, wild boars, and bulls. Charles I. turned out wild boars in the New Forest, Hampshire; but they were destroyed in the civil wars.

On the continent the wild boar is hunted with dogs, or killed by surprise during the night, when the moon shines. As he runs slowly, leaves a strong odour behind him, and defends himself against the dogs, and often wounds them dangerously, fine hunting dogs are unnecessary, and would have their nose spoiled, and acquire a habit of moving slowly by hunting him. Mastiffs, with very little training, are sufficient. The oldest, which are known by the tract of their feet, should only be attacked: A young boar of three years old is difficult to hunt down; because he runs very far without stopping. But the older boars do not run far, allow the

* Survey of
Husbandry,
1. 171.

† Art of
Husbandry
vol. i.
p. 117.

Sus.

the dogs to run near, and often stop to repel them. During the day, he commonly remains in his soil, which is in the most sequestered part of the woods. He comes out in the night in quest of food. In summer, when the grain is ripe, it is easy to surprise him among the cultivated fields, which he frequents every night. As soon as he is slain, the hunters cut off his testicles, the odour of which is so strong, that in a few hours it would infect the whole flesh. The snout of an old boar is the only part that is esteemed; but every part of the castrated and young boar, not exceeding one year fed, makes delicate eating. The pork of the domestic boar is still worse than that of the wild boar; and it can only be rendered fit for eating by castration and fattening. The ancients castrated the young boars which they could carry off from their mothers, and returned them to the woods, where they grew fat, and their pork was much better than that of domestic hogs. There are several varieties of the common hog.

2. The *ethiopicus*, or Ethiopian hog, with small tusks in the lower jaw, very large ones in the upper, in old boars bending towards the forehead in form of a semicircle: no fore teeth: nose broad, depressed, and almost of a horny hardness: head very large and broad: beneath each eye a hollow, formed of loose skin, very soft and wrinkled; under these a great lobe or wattle, lying almost horizontal, broad, flat, and rounded at the end, placed so as to intercept the view of any thing below from the animal. Between these and the mouth on each side, there is a hard callous protuberance. The mouth is small: skin dusky: bristles disposed in fasciculi, of about five each; longest between the ears and on the beginning of the back, thinly dispersed on the rest of the back. Ears large and sharp pointed, inside lined with long whitish hairs: tail slender and flat, not reaching lower than the thighs, and is covered with hairs disposed in fasciculi. Body longer, and legs shorter, than in the common swine: its whole length 4 feet 9 inches; height before, 2 feet 2 inches: but in a wild state, it grows to an enormous size.—These animals inhabit the hottest parts of Africa, from Senegal to Congo, also the island of Madagascar. We know little of their nature; but they are represented as very fierce and swift, and that they will not breed with the domestic sow.

3. The *tajassu*, pecary, or Mexican hog, with four cutting teeth above, and six below: two tusks in each jaw; those in the upper jaw pointing down, and little apparent when the mouth is shut; the others hid: length from nose to the end of the rump about three feet: head not so taper as in common swine: ears short and erect: body covered with bristles, stronger than those of the European kind, and more like those of a hedge-hog; they are dusky, surrounded with rings of white; those on the top of the neck and back are near five inches long, grow shorter on the sides; the belly almost naked; from the shoulders to the breast is a band of white: no tail: on the lower part of the back is a gland, open at the top, discharging a fetid ichorous liquor; this has been by mistake called a *navel*.—Inhabits the hottest parts of South America, and some of the Antilles: lives in the forests on the mountains: not fond of mire or marshy places: less fat than the common hog. These animals go in great droves. They are very fierce, and will fight stoutly with the beasts of prey: the jaguar, or American leopard, is their mortal enemy; often the body of that animal is found with several of these hogs slain in combat. Dogs will scarce attack this animal: if wounded, it will turn on the hunters. They feed on fruits and roots; also on toads and all manner of serpents, which they hold with their fore-feet, and skin with great dexterity. The flesh is reckoned very good

food; but all writers agree that the dorsal gland must be cut out as soon as the animal is killed, or the flesh will become so infected as not to be eatable. The Indian name of this species is *paquiras*, from whence seems to be derived that of *pecary*. There are more varieties of this species, the *tajassu minor* and the *patera*.

4. The *babyrussa*, or Indian hog, with four cutting teeth in the upper, six in the lower jaw; ten grinders to each jaw; in the lower jaw two tusks pointing towards the eyes, and standing near eight inches out of their sockets; from two sockets on the outside of the upper jaw two other teeth, twelve inches long, bending like horns, their ends almost touching the forehead: ears small, erect, sharp-pointed: along the back are some weak bristles; on the rest of the body only a sort of wool, such as is on the lambs: the tail long, ends in a tuft, and is often twisted: the body plump and square. Inhabits Buero, a small isle near Amboina: it is also found in Celebes, but neither on the continent of Asia or Africa; what M. de Buffon takes for it is the Ethiopian boar. They are sometimes kept tame in the Indian isles: live in herds: have a very quick scent: feed on herbs and leaves of trees; never ravage gardens like other swine: their flesh well-tasted. When pursued and driven to extremities, they rush into the sea, swim very well, and even dive, and pass thus from isle to isle. In the forests they often rest their heads, by hooking their upper tusks on some bough. The tusks, from their form, are useless in fight.

SUSA, the ancient royal residence of the kings of Persia, built by Darius Hytaspis, according to Pliny; though he probably only restored it, being a very ancient city, founded by Tithonus father of Memnon. It was in compass 120 stadia, of an oblong quadrangular form, with a citadel called *Memnoneum*. In scripture it is called *Susan*, the royal citadel, from the great number of lilies growing in that district (Athenæus); situate on the river Uhlai, or Eulæus (Daniel): and the Spaniards call at this day a lily *asufena* (Pinedo). Susa was the winter, as Echatana was the summer, residence of the kings of Persia, (Xenophon, Strabo, Plutarch). Here the kings kept their treasure, (Herodotus.) Now called *Tufter*.

SUSPENSION, in Scots law. See LAW, n° clxxxv. 5, 6, and 7.

SUSSEX, a county of England, deriving its name from its situation in respect of the other Saxons, and called *Suffex*, i. e. the country of the South Saxons, has Hampshire on the west, the British channel on the south, Surry on the north, and Kent on the east. Its length is 65 miles, its breadth 30, and its circumference 170. It is divided into 6 rapes, and these into 65 hundreds, in which are 342 parishes, of which 123 are vicarages, one city, 16 market-towns, 1,140,000 acres, and about 120,000 souls. It has few good ports, though it lies along the channel for 65 miles, which is its greatest length, the coast being encumbered in many places with rocks; and where it is more open, such quantities of sand are thrown upon it by the south-west winds, and the harbours so choaked up, that they will not admit vessels of any great draught or burden. The county is well watered by the rivers Arun, Adar, Ouse, Rother, Lavant, Cuckmeer, Ashburn, and Aften, by which it is well supplied with fish, as well as from the sea. Hence different places of the county are famed for different sorts of fish, as the Arun for mullets, which enter it from the sea in summer in shoals, and by feeding upon a particular kind of herb become extremely delicious: Chichester for lobsters, Selsey for cockles, Amberley for trout, Pulborough for eels, Rye for herrings, and the county in

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Camden's
Britannia,
vol. i.

p. 192.

Suffex, general for carp. It is remarkable, that all the rivers above-mentioned rise and fall into the sea within the county.

Sutherland The air, as well as the soil, is various in different parts of the county. Upon the coast the air is aguish, upon the hills and downs pleasant and wholesome; but somewhat moist and foggy in the valleys, the soil being deep and rich, and the vegetation in summer very vigorous. The downs in some places are very fertile in corn and grass; in others they feed great flocks of sheep, whose flesh and wool are very fine; but of the latter no inconsiderable quantity is clandestinely exported to France. In the Weald and the valleys the roads are very deep, especially in winter. In the north quarter are many woods, and some forests in other places; whence the king's yards are supplied with the largest and best timber in England, beside what is made into charcoal and consumed in the iron-works; for on the east side is plenty of iron ore, with furnaces, forges, and mills for manufacturing it. The gunpowder of this county is said to excel that of any other. Those delicious birds called *wheat-eats* are bred in this shire; they are no bigger than a lark, but almost an entire lump of fat. That part now called the *Wild or Weald* of Suffex, was anciently a mere desert for hogs and deer, of great extent, taking in a part of Kent and Surry; and was called *Anderida Silva*, *Coid Andred*, and *Andradswald*, from *Anderida* an adjoining city. This county is in the home-circuit and diocese of Chichester, giving title of earl to the family of Yelverton, and sends 28 members to parliament, viz, two for the county, two for the city of Chichester, and two for each of the following towns, Hoveham, Lewes, Bramber, East-Grinstead, Midhurst, Shoreham, Staining, Arundel, Hastings, Rye, Winchelsea, and Seaford; of which the four last are cinque-ports.

SUTHERLAND, one of the most northerly counties of Scotland. Including Strathnavern, it borders on Caithness to the north and north-east, is bounded by the ocean on the north, the country of Assynt on the west, Ross on the south, and by the German sea on the east and south-east. It stretches about 70 miles in length, and 40 in breadth; is generally hilly, tho' in many parts arable; well watered with small rivers and streams replete with fish, and exhibiting about 60 lakes, the habitation of various fish, swans, ducks, geese, &c. One of the largest of these is Lochshin, extending 18 miles in length. Some of them are interspersed with small verdant islands, which in summer yield a very agreeable prospect. On the coast are many commodious harbours, and all the bays swarm with fish; nay, the sea in this place produces some valuable pearls. Sutherland affords iron-stone, freestone, lime-stone, and slate, in abundance. Here are also quarries of marble, and mines of coal, though the people use turf and peat for fuel. Lead ore, impregnated with silver, and even some gold, hath been found in this province, together with crystals and pebbles.

The air is so temperate, and the soil so good, that saffron has here been brought to perfection. Many parts of the country are remarkably fruitful in corn, and the pasturage is excellent everywhere. Besides three great forests, there are many smaller woods in Sutherland, abounding with deer and other game. On the hills are fed numerous flocks of sheep and black cattle; small, yet sweet and juicy. There is one bird peculiar to this shire, called *knag*, which resembles a parrot, and digs its nest with its beak in the trunks of oaks. The northern part, called *Strathnavern*, and separated from the rest by a ridge of mountains, is bounded on the north by the Deucalionian sea, on the west by the channel called the *Minch*, on the east by Caithness, and on the south by Assynt. The length of it, from east to west, amounts to 34

miles; but the breadth from north to south does not exceed 12 in some places. It is very hilly; and the mountains are so high, that the snow remains on the tops of them till midsummer. It is watered by Navern, from whence it derives its name; as this district gives a title to the eldest son of the earl of Sutherland. Here are several woods, frequented by deer and other game, which the people take great delight in hunting. Iron-mines have been worked in some places, but to no great advantage. Strathnavern has many fresh water lakes or lochs; the chief of which are Loch Navern and Loch Lyel: there are several islands on the northern coast; and in various parts of the country we see monuments of victories obtained over the Danes or other foreign invaders. Sutherland boasts of some towns, and a great many villages. The people are numerous, hardy, bold, and enterprising; courteous to strangers; cheerful, open, frugal, and industrious. They, as well as their neighbours of Caithness, speak the language, and wear the garb, used in the Lowlands of Scotland. They carry on a considerable salmon-fishery. They drive a traffic with their black cattle, sheep, and horses, at the neighbouring fairs; but export their corn, barley, salt, coal, salmon, salted beef, butter, cheese, wool-skins, hides, and tallow. Here are provisions of all sorts in plenty; and so cheap through all this country, that a gentleman may keep house and live much more sumptuously for 200 l. a-year than he can live for three times the money in the south of England.

SUTLER, in war, one who follows the army, and furnishes the troops with provision. Sutlers pitch their tents, or build their huts, in the rear of each regiment, and about head-quarters.

SUTRIUM (anc. geog.), a famous city, and an ancient colony of the Romans, the key of Etruria; founded about seven years after the taking of Rome by the Gauls (Velleius). Now *Sutri* in St Peter's patrimony, on the river Pozzolo; surrounded on every side with rocks, 24 miles to the north-west of Rome.

SUTTON (Samuel), was born at Alfretton in Derbyshire, and going into the army served under the duke of Marlborough in Queen Anne's wars with great credit. He afterwards came to London, commenced brewer, and kept a coffee-house in Aldergate-street, which was well frequented by the learned men of that time, by whom Mr Sutton was much respected, as a man of strong natural parts and uncultivated genius. About the year 1740 he schemed a very simple and natural method for extracting the foul air from the wells of ships, by pipes communicating with the fire-places of the coppers; which operated as long as any fire was kept burning for the ship's use. He took out a patent in 1744, to secure the profits of his invention; and died about the year 1752.

SUTTON's Air-pipes. See *Air-Pipes*.

SUTURE, in anatomy, a kind of articulation peculiar to the cranium or skull. See *ANATOMY*, Part I. Sect. ii. *passim*.

SUTURE, in surgery, a method of uniting the lips of wounds together. See *SURGERY*.

SWABBER, an inferior officer on board ships of war, whose employment it is to see that the decks are kept clean and neat.

SWABIA. See *SUABIA*.

SWALLOW, in natural history, is classed under the genus of *HIRUNDO*, under which article the different species have been already described. Concerning this bird, one curious question, however, still remains to be discussed, What becomes of it in the winter? Upon this subject there are three opinions. Some say that it migrates to a warmer climate; winter?

Sutler
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Swallow.

Question,
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Swallow. mate; some, that it retires to hollow trees and caverns, where it lies in a torpid state; and others have affirmed, that it lies in the same state in the bottom of lakes and under the ice. The first opinion is supported by Marfigli, Ray, Willoughby, Catesby, Reaumur, Adanson, Buffon, &c. The first and second opinion are both adopted by Pennant and White. The third is sanctioned by Schæffer, Hevelius, Derham, Klein, Ellis, Linnæus, Kalm: and the second and third have been strongly defended by the honourable Daines Barrington.

Though we cannot help giving a preference to that opinion which appears the most probable, yet we do not think that any one of them is established upon such evidence as so curious a subject requires, and as the advanced state of natural history would lead us to expect. We shall therefore state the arguments upon which each opinion is founded as fairly and distinctly as we can, and as often as possible in the very words of their respective advocates. By doing so, we shall place the whole subject before the eyes of our readers, who will thus have an opportunity of examining it attentively, and of making such observations and experiments as may lead to the truth.

First opinion stated, that they migrate to warm climates. Those who assert that the swallow migrates to a warmer country in winter, argue in this manner: That many birds migrate, is a fact fully proved by the observations of natural historians (see MIGRATION). Is it not more probable, therefore, that swallows, which disappear regularly every season, retire to some other country, than that they lie in a state of torpor in caverns or lakes? But this opinion does not rest on probability, it is founded on facts.

Natural History of Selborne, p. 64. We often see them collected in great flocks on churches, rocks, and trees, about the time when they annually disappear. The direction of their flight has been observed to be southward. Mr White, the ingenious historian of Selborne, travelling near the coast of the British Channel one morning early, saw a flock of swallows take their departure. At the beginning of his journey he was environed with a thick fog; but on a large wild heath the mist began to break, and discovered to him numberless swallows, clustered on the standing bushes, as if they had roosted there: as soon as the sun burst out, they were instantly on wing, and with an easy and placid flight proceeded towards the sea. After this he saw no more flocks, only now and then a straggler.

Gent. Mag. for 1796. Mr Laskey of Exeter observed attentively the direction which a flock of swallows took in the autumn of 1793. On the 22d of Sept. about seven o'clock in the morning, the wind being easterly, accompanied with a cold drizzling rain, Mr Laskey's house was entirely covered with house-swallows. At intervals large flocks arrived and joined the main body, and at their arrival an unusual chirping commenced. The appearance of the whole company was so lethargic, that he found it an easy matter to catch a considerable number of them, which he kept in a room all that day. By heating the room they all revived: he opened four of them, and found their stomachs quite full. The main body occupied the house top all day, except for two hours. About half an hour after nine on the morning of the 23d, there was a great commotion, with very loud chirping, and within a few minutes after, the whole multitude took their flight, in a direct south-east direction, having ascended to a great height in the atmosphere. He let go the birds which he had caught, at certain intervals till four o'clock, and they all flew toward the same quarter.

Not only has the direction of their flight been observed, but they have also been found on their passage at a great distance from land. Mr Adanson informs us, that

about 50 leagues from the coast of Senegal four swallows settled upon the ship on the 6th of October; that these birds were taken; and that he knew them to be European swallows, which, he conjectures, were returning to the coast of Africa. Sir Charles Wager's authority may also be appealed to: "Returning home (says *Philosophical Transactions*, vol. liii. he) in the spring of the year, as I came into soundings in our channel, a great flock of swallows came and settled on all my rigging; every rope was covered, they hung on one another like a swarm of bees; the decks and carving were filled with them. They seemed almost famished and spent, and were only feathers and bones; but, being recruited with a night's rest, took their flight in the morning." This vast fatigue proves that their journey must have been very great, considering the amazing swiftness of these birds: in all probability they had crossed the Atlantic ocean, and were returning from the shores of Senegal, or other parts of Africa; so that this account from that most able and honest seaman, confirms the later information of Mr Adanson.

Mr Kalm, who is an advocate for the opinion that swallows lie immersed in lakes during the winter, acknowledges, that in crossing the Atlantic from Europe a swallow lighted on the ship on the 2d September, when it had passed only two-thirds of the ocean. Since, therefore, swallows have been seen assembled in great flocks in autumn flying off in company towards southern climes, since they have been found both in their passage from Europe and returning again, can there be any doubt of their annual migration? —For Mr Barrington's objections to this opinion, see MIGRATION, p. 5.

Second opinion, that some lie in caverns in a torpid state. The second notion (says Mr Pennant) has great antiquity on its side. Aristotle and Pliny give it as their belief, that swallows do not remove very far from their summer habitation, but winter in the hollows of rocks, and during that time lose their feathers. The former part of their opinion has been adopted by several ingenious men; and of late several proofs have been brought of some species, at least, having been discovered in a torpid state. Mr Collinson favoured us with the evidence of three gentlemen, eye-witnesses to numbers of sand martins being drawn out of a cliff on the Rhine, in the month of March 1762. And the honourable Daines Barrington communicated to us the following fact, on the authority of the late Lord Belhaven, That numbers of swallows have been found in old dry walls and in sand-hills near his Lordship's seat in East Lothian; not once only, but from year to year; and that when they were exposed to the warmth of a fire, they revived. We have also heard of the same annual discoveries near Morpeth in Northumberland, but cannot speak of them with the same assurance as the two former: neither in the two last instances are we certain of the particular species.

"Other witnesses crowd on us to prove the residence of those birds in a torpid state during the severe season. First, In the chalky cliffs of Sussex; as was seen on the fall of a great fragment some years ago. Secondly, In a decayed hollow tree that was cut down, near Dolgelli, in Merionethshire. Thirdly, In a cliff near Whitby, Yorkshire; where, on digging out a fox, whole bushels of swallows were found in a torpid condition. And, lastly, The reverend Mr Conway of Sychton, Flintshire, was so obliging as to communicate the following fact: A few years ago, on looking down an old lead mine in that county, he observed numbers of swallows clinging to the timbers of the shaft, seemingly asleep; and on flinging some gravel on them, they just moved, but never attempted to fly or change their place: this was between All Saints and Christmas.

"These

Swallow.

"These are doubtless the lurking places of the later hatches, or of those young birds which are incapable of distant migrations. There they continue insensible and rigid; but like flies may sometimes be reanimated by an unseasonable hot day in the midst of winter: for very near Christmas a few appeared on the moulding of a window of Merton college, Oxford, in a remarkably warm nook, which prematurely set their blood in motion, having the same effect as laying them before a fire at the same time of year. Others have been known to make this premature appearance; but as soon as the cold natural to the season returns, they withdraw again to their former retreats.

"The above are circumstances we cannot but assent to, though seemingly contradictory to the common course of nature in regard to other birds. We must, therefore, divide our belief relating to these two so different opinions; and conclude, that one part of the swallow-tribe migrate, and that others have their winter-quarters near home. If it should be demanded, why swallows alone are found in a torpid state, and not the other many species of soft billed birds, which likewise disappear about the same time? reasons might be assigned:"

4
Third opinion, that some lie immersed in water.

The third opinion we shall state and support in the words of Mr Kalm. "Natural history (says he), as all other histories, depends not always upon the intrinsic degree of probability, but upon facts founded on the testimony of people of noted veracity.—Swallows are seldom seen sinking down into the water; swallows have not such organs as frogs or lizards, which are torpid during winter; *ergo*, swallows live not, and cannot live, under water.—This way of arguing, I believe, would carry us, in a great many cases, too far: for though it is not clear to every one, it may however be true; and lizards and frogs are animals of a class widely different from that of birds, and must therefore of course have a different structure; hence it is they are classed separately. The bear and the marmot are in winter in a torpid state, and have, however, not such organs as lizards and frogs; and nobody doubts of their being, during some time, in the most rigid climates, in a torpid state: for the Alpine nations hunt the marmots frequently by digging their holes up; and find them so torpid, that they cut their throats, without their reviving or giving the least sign of life during the operation; but when the torpid marmot is brought into a warm room, and placed before the fire, it revives from its lethargy. The question must therefore be decided by facts; nor are these wanting here. Dr Wallerius, the celebrated Swedish chemist, informs us, That he has seen, more than once, swallows assembling on a reed, till they were all immersed and went to the bottom; this being preceded by a dirge of a quarter of an hour's length. He attests likewise, that he had seen a swallow caught during winter out of a lake with a net, drawn, as is common in northern countries, under the ice; this bird was brought into a warm room, revived, fluttered about, and soon after died.

"Mr Klein applied to many farmers-general of the king of Prussia's domains, who had great lakes in their districts, the fishery in them being a part of the revenue. In winter the fishery thereon is the most considerable under the ice, with nets spreading more than 200 or 300 fathoms, and they are often wound by screws and engines on account of their weight. All the people that were questioned made affidavits upon oath before the magistrates. First, The mother of the countess Lehndorf said, that she had seen a bundle of swallows brought from the Frische-Haff (a lake communicating with the Baltic at Pillaw), which, when brought into a moderately warm room, revived and fluttered about. Secondly, Count Schileben gave an instrument on stamped

paper, importing, that by fishing on the lake belonging to his estate of Gerdauen in winter, he saw several swallows caught in the net, one of which he took up in his hand, brought it into a warm room, where it lay about an hour, when it began to stir, and half an hour after, it flew about in the room. Thirdly, Farmer-general (Amtman) Witkowski made affidavit, that, in the year 1740, three swallows were brought up with the net in the great pond at Didlaken; in the year 1741 he got two swallows from another part of the pond, and took them home (they being all caught in his presence); after an hour's space they revived all in a warm room, fluttered about, and died in three hours after. Fourthly, Amtman Bonke says, that having had the estate of Kleskow in farm, he had seen nine swallows brought up in the net from under the ice, all which he took into a warm room, where he distinctly observed how they gradually revived; but a few hours after they all died. Another time his people got likewise some swallows in a net, but he ordered them to be again thrown into the water. Fifthly, Andrew Rutta, a master fisherman at Oletsko, made affidavit, in 1747, that 22 years ago, two swallows were taken up by him in a net, under the ice, and, being brought into a warm room, they flew about. Sixthly, Jacob Kosulow, a master fisherman at Stradauen, made affidavit, that, in 1736, he brought up in winter, in a net, from under the ice of the lake at Raski, a seemingly dead swallow, which revived in half an hour's time in a warm room; and he saw, in a quarter of an hour after, the bird grow weaker, and soon after dying. Seventhly, I can reckon myself (says our author) among the eye-witnesses of this paradox of natural history. In the year 1735, being a little boy, I saw several swallows brought in winter by the fishermen from the river Vistula to my father's house; where two of them were brought into a warm room, revived, and flew about. I saw them several times settling on the warm stove (which the northern nations have in their rooms); and I recollect well, that the same forenoon they died, and I had them, when dead, in my hand. In the year 1754, after the death of my uncle Godefroy Wolf, captain in the Polish regiment of foot-guards, being myself one of his heirs, I administered for my co-heirs several estates called the *Starosty of Dischau*, in Polish Prussia, which my late uncle farmed under the king. In January, the lake of Lybshaw, belonging to these estates, being covered with ice, I ordered the fishermen to fish therein, and in my presence several swallows were taken, which the fishermen threw in again; but one I took up to myself, brought it home, which was five miles from thence, and it revived, but died about an hour after its reviving.

"These are facts attested by people of the highest quality, by some in public offices, and by others who, though of a low rank, however, made these affidavits upon oath. It is impossible to suppose indiscriminately that they were prompted, by views of interest, to assert as a fact a thing which had no truth in it. It is therefore highly probable, or rather incontestably true, that swallows retire in the northern countries, during winter, into the water, and stay there in a torpid state till the return of warmth revives them again in spring. The question therefore, I believe, ought for the future to be thus stated: The swallows in Spain, Italy, France, and perhaps some from England, remove to warmer climates; some English ones, and some in Germany and other mild countries, retire into clefts and holes in rocks, and remain there in a torpid state. In the colder northern countries the swallows immerse in the sea, in lakes, and rivers; and remain in a torpid state, under ice, during winter. There are still some objections to this latter asser-

Swallow. assertion, which we must remove. It is said, Why do not rapacious fish, and aquatic quadrupeds and birds, devour these swallows? The answer is obvious, swallows choose only such places in the water for their winter-retreat as are near reeds and rushes; so that sinking down there between them and their roots, they are by them secured against the rapaciousness of their enemies. But others object, Why are not these birds caught in such fresh waters as are continually harassed by nets? I believe the same answer which has been made to the first objection will serve for this likewise. Fishermen take care to keep off with their nets from places filled with reeds and rushes, for fear of entangling and tearing their net; and thus the situation of swallows under water, is the reason that they are seldom disturbed in their silent winter-retreats. What confirms this opinion still more is, that swallows were never caught in Prussia according to the above-mentioned affidavits, but with those parts of the net which passed near to the reeds and rushes; and sometimes the swallows were yet fastened with their feet to a reed, when they were drawn up by the net. As to the argument taken from their being so long under water without corruption, I believe there is a real difference between animals suffocated in water and animals being torpid therein. We have examples of things being a long time under water; to which we may add the intense cold of these northern regions, which preserves them. Who would have thought that snails and polypes might be dissected, and could reproduce the parts severed from their bodies, if it was not a fact? Natural history ought to be studied as a collection of facts, not as the history of our guesses or opinions. Nature varies in an infinite manner; and Providence has diversified the instinct of animals and their economy, and adapted it to the various seasons and climates."

5
This question ought to be determined, not by reasoning, but by experiment.

With Mr Kalm's concluding observations we heartily concur. Natural history ought to be studied as a collection of facts; and it was from this very notion that we have stated the above mentioned opinions so fully, and brought together the facts which the best advocates for each opinion have judged most proper for supporting them. We are sensible of the great improbability of the third opinion, and know that many arguments have been used to prove its absurdity: such as these, The swallow is lighter than water, and therefore cannot sink; if it moults at all, it must moult under water during its torpid state, which is very improbable; there is no instance of land animals living so long under water without respiration. Many other arguments of the same sort have been advanced, and certainly afford a short way of deciding the question; but unless they were sufficient to prove the immersion of swallows a physical impossibility, they are of no force when opposed to the evidence of testimony, if there be no cause to suspect the witness of inaccuracy or design. The true way to refute such an opinion is by accurate observation and experiment. We have not heard of any accurate inquiries being made by philosophers in those northern countries where swallows are said to pass the winter under water. The count de Buffon, indeed, shut up some swallows in an ice-house by way of experiment, which died in a few days; but as he does not tell us what precautions he took to make the experiment succeed, it is not intitled to any attention.

Mr John Hunter made a very judicious experiment on the banks of the Thames, which is described by a correspondent in the Gentleman's Magazine, who asserts that he had it from Mr Hunter himself.

Gentleman's Magazine, May 1796.

One year in the month of September, he prepared a room, with every accommodation and convenience which he could contrive, to serve as a dormitory for swallows, if they were disposed to sleep in winter. He placed in the centre a large

tub of water with twigs and reeds, &c. which reached to the bottom. In the corners of the room he contrived artificial caverns and holes, into which they might retire; and he laid on the floor, or suspended in the air, different lengths of old wooden pipes, which had formerly been employed in conveying water through the streets, &c.

Swallow. 6
Mr Hunter's experiment ingenious.

When the receptacle was rendered as complete as possible, he then engaged some watermen to take by night a large quantity of the swallows that hang upon the reeds in the Thames about the time of their departure. They brought him, in a hamper, a considerable number; and had so nicely hit the time of their capture, that on the very day following there were none to be seen.

He put the swallows into the room so prepared, where they continued to fly about, and occasionally perch on the twigs, &c. But not one ever retired into the water, the caverns, holes, or wooden pipes, or shewed the least disposition to grow torpid, &c. In this situation he let them remain till they all died but one. This, appearing to retain some vigour, was set at liberty; when it mounted out of sight, and flew away. All the birds lay dead scattered about the room; but not one was found asleep or torpid, or had, if the correspondent remembers, so much as crept into any of the receptacles he had so provided.

This experiment was ingenious, and certainly does render the doctrine of immersion much more improbable; but it is not decisive; for it may still be urged by the advocates for that doctrine, as Mr Kalm has done, that it may only be in the colder countries where swallows retire into the water. We formerly said that none of the three opinions are supported by such evidence as to satisfy the mind completely. Opinions which respect events which happen every year ought to be confirmed by a great number of observations, and not by a few instances divested of almost all their concomitant circumstances. Can no better proofs be brought to prove the migration of swallows than those of Adanson and Sir Charles Wager, or the circumstances mentioned by Mr White and Mr Laskey respecting their disappearing? We ought not merely to know that some swallows have taken a southerly flight in autumn, that some have been found at a great distance from land in the spring, or in harvest; but we ought to know to what countries they actually retire. Before we can rest satisfied, too, that it is a general fact that swallows remain in a torpid state during winter, either in caverns or in the bottom of lakes, &c. we must have more proofs; we must know what species of swallows they are said to be, in what countries this event takes place, and several other circumstances of the same kind.

8

We cannot help being of opinion that much remains to be done in order properly to ascertain what becomes of the swallows in Europe during winter. It would be necessary, in the first place, to know accurately what are the countries in which swallows are found. 2. Do they remain visible the whole year? or, if they disappear, at what season does this happen, and when do they appear again? 3. Do they ever appear while a strong north wind blows, or do they only come in great numbers with a south wind? We will endeavour to answer some of these questions in part; but must regret, that all the information on this subject which we have been able to cull from the best writers in natural history is very scanty; and we merely give it by way of specimen, hoping that future observations will soon render it more complete.

Many things yet remain to be done in order to determine this point.

There are five species which visit Britain during the summer months; the common or chimney swallow, the martin, sand martin, swift, and goat-sucker. The chimney swallow frequents almost every part of the old continent; being known (says Dr Latham) from Norway to the Cape of

9

A few important facts stated.

Swallow. of Good Hope on the one side, and from Kantschatka to India and Japan on the other. It is also found in all parts of North America, and in several of the West Indian Islands. In Europe it disappears during the winter months. It appears generally a little after the vernal equinox; but rather earlier in the southern, and later in the northern latitudes. It adheres to the usual seasons with much regularity; for though the months of February and March should be uncommonly mild, and April and May remarkably cold, it never deviates from its ordinary time. In the cold spring of 1740 some appeared in France before the insects on which they feed had become numerous enough to support them, and great numbers died †. In the mild and even warm spring of 1774 they appeared no earlier than usual. They remain in some warm countries the whole year. Kolben assures us that this is the case at the Cape of Good Hope; but (he says) they are more numerous in winter. Some birds of this species live, during winter, even in Europe; for example, on the coast of Genoa, where they spend the night in the open country on the orange shrubs.

† Buffon's
Natural
History of
Birds,
vol. vi.
p. 527.

2. The *martins* are also widely diffused through the old continent; but the countries where they reside or visit have not been marked by naturalists with much attention. 3. The *sand martins* are found in every part of Europe, and frequently spend the winter in Malta †. Two birds of this species were seen in Perigord in France, on the 27th December 1775, when there was a southerly wind, attended with a little rain †. 4. The *swift* visits the whole continent of Europe; has also been observed at the Cape of Good Hope, and in Carolina in North America. 5. The *goat-suckers* are not very common birds, yet are widely scattered. They are found in every country between Sweden and Africa: they are found also in India. In April the south-west wind brings them to Malta, and in autumn they repass in great numbers.

Transactions of the
Linnean
Society,
vol. i.

Mr Markwick of Catsfield, near Battle in Suffex, has drawn up an accurate table, expressing the day of the month on which the birds, commonly called *migratory*, appeared in spring, and disappeared in autumn, for 16 years, from 1763 to 1783 inclusive. The observations were made at Catsfield. From this table we shall extract the dates for five years, and add the very few observations which we have been able to collect respecting the time when the swallow appears and disappears in other countries.

1779.			1781.		
	First seen.	Last seen.		First seen.	Last seen.
Chim. Swal.	Ap. 14.	Oct. 29.	Sand Mart.	Ap. 26.	Sep. 1.
Martins	14.	15.	Swift	May 12.	1.
Sand Mart.	May 7.			1782.	
Swift	9.		Chim. Swal.	Ap. 22.	Sep. 1.
	1780.		Martins	26.	Nov. 2.
Chim. Swal.		Nov. 3.	Sand Mart.	May 15.	Aug. 28.
Martins	Ap. 29.	3.	Swift	18.	28.
Sand Mart.	8.	Sep. 8.		1783.	
Swift	May 6.	8.	Chim. Swal.	Ap. 13.	Nov. 6.
	1781.		Martins	May 1.	6.
Chim. Swal.	Ap. 8.	Oct. 15.	Sand Mart.	July 25.	Sep. 1.
Martins	May 12.	Sep. 7.	Swift	May 13.	Nov. 6.

Chim. Swal. Swifts. Martins. S. Mart.
Appear about

† Buffon,
ibid.
† White's
Natural
History of
Selborne.
§ Buffon,
ibid.

In Burgundy †
In Selborne, Hampshire † Ap. 4. Ap. 24. Ap. 30.
In South Zele, Devonshire † 25. May 1. May 15.
In Blackburn, Lancashire † 29. Ap. 28.
In Upsal in Sweden § May 9.

Were tables of the same kind made in every different country, particularly within the torrid zone, it would be easy to determine the question which we have been considering. To many, perhaps, it may not appear a matter of such importance as to be worth the labour. We acknow-

ledge it to be rather a curious than an important inquiry; yet it is one which must be highly gratifying to every mind that can admire the wisdom of the Great Architect of nature. The instinct of the swallow is indeed wonderful: it appears among us just at the time when insects become numerous; and it continues with us during the hot weather, in order to prevent them from multiplying too much. It disappears when these insects are no longer troublesome. It is never found in solitude; it is the friend of man, and always takes up its residence with us, that it may protect our houses and our streets from being annoyed with swarms of flies.

SWALLOW-WORT, in botany. See ASCLEPIAS.

SWAMMERDAM (John), a celebrated and learned natural philosopher, was the son of John James Swammerdam, an apothecary and famous naturalist of Amsterdam, and was born in 1637. His father intended him for the church, and with this view had him instructed in Latin and Greek; but he, thinking himself unequal to so important a task, prevailed with his father to consent to his applying himself to physic. As he was kept at home till he should be properly qualified to engage in that study, he was frequently employed in cleaning his father's curiosities, and putting every thing in its proper place. This inspired our author with an early taste for natural history; so that, not content with the survey of the curiosities his father had purchased, he soon began to make a collection of his own, which he compared with the accounts given of them by the best writers. When grown up, he seriously attended to his anatomical and medical studies; yet spent part of the day and the night in discovering, catching, and examining the flying insects proper to those times, not only in the province of Holland, but in those of Guelderland and Utrecht. — Thus initiated in natural history, he went to the university of Leyden in 1651; and in 1663 was admitted a candidate of physic in that university. His attention being now engaged by anatomy, he began to consider how the parts of the body, prepared by dissection, could be preserved, and kept in constant order for anatomical demonstration; and herein he succeeded, as he had done before in his nice contrivances for dissecting and managing the minutest insects. Our author afterwards made a journey into France, where he spent some time at Saumur, and where he became acquainted with several learned men. In 1667 he returned to Leyden, and took his degree of Doctor of Physic. The next year the grand duke of Tuscany being in Holland in order to see the curiosities of the country, came to view those of our author and his father; and on this occasion Swammerdam made some anatomical dissections of insects in the presence of that prince, who was struck with admiration at our author's great skill in managing them, especially at his proving that the future butterfly lay with all its parts neatly folded up in a caterpillar, by actually removing the integuments that covered the former, and extricating and exhibiting all its parts, however minute, with incredible ingenuity, by means of instruments of inconceivable fineness. On this occasion the duke offered our author 12,000 florins for his share of the collection, on condition of his removing them himself into Tuscany, and coming to live at the court of Florence; but Swammerdam, who hated a court life, declined his highness's proposal. In 1663, he published a General History of Insects. About this time, his father began to take offence at his inconsiderately neglecting the practice of physic, which might have supported him in affluence; and would neither supply him with money nor clothes. This reduced him to some difficulties. In 1675 he published his History of the Ephemeras; and his father dying the same year, left him a fortune sufficient for his support.

Swallow,
Swammer-
dam

Swan
||
Sweden.
port : but he did not long survive him, for he died in 1682. Gaubius gave a translation of all his works from the original Dutch into Latin, from which they were translated into English, in folio, in 1758. The celebrated Boerhaave wrote his life.

SWAN, in ornithology. See ANAS.

SWANPAN, or Chinese ABACUS; an instrument for performing arithmetical operations, described by Du Halde in his History of China.

It is composed of a small board, crossed with 10 or 12 parallel rods or wires, each strung with ivory balls, which are so divided by a partition in the middle, that two are on one side of it, and five on the other. The two in the upper part stand each for five units, and each of the five in the lower part for one. "In joining and separating these balls, they reckon much as we do with counters; but, according to our author, more expeditiously than Europeans do even with figures." This is hardly credible; but if all the Chinese weights and measures be decimally divided, as by his very lame description of the *swanpan* they would appear to be, it is easy to conceive how computation may be made by this instrument very expeditiously. The instrument, too, may be so contrived as to suit any division of weights and measures, and in that form be useful to the blind; but as we have elsewhere given descriptions of superior instruments, for their accommodation (see BLIND) it is needless to offer in this place any improvement of the *swanpan*.

SWANEMOTE, SWAINMOTE, or SWEINMOTE. See FOREST-COURTS.

SWEARING. See OATH.

SWEAT, a sensible moisture issuing from the pores of the skins of living animals.

The excess of it dries and weakens the body, deprives the humours of their watery parts, and induces the blood to an inflammatory and atrabiliary disposition. A sudden suppression of it will equally hurt as well as a suppression of perspiration.

SWEATING SICKNESS, a disorder which appeared in England about the year 1481, and was by foreigners called the *English sweat*. It returned again in 1485; then in 1506; afterwards in 1517. It appeared again in 1528, or 1529, at which time alone it spread itself to the Netherlands and Germany: a circumstance which shows the impropriety of calling it the *English sweat*, in Latin *sudor Anglicanus*; besides, Sennertus takes notice, that it spread as far as Denmark, Norway, and France. It raged again in 1548. And the last return of it in London was in 1551, when it was so violent as in one day to take off 120 of the inhabitants of Westminster. Some were seized abroad, and cut off in the road, others at home. Some when awake, others when fast asleep. Some died in a moment, and others in one, two, three, four, or more hours after they began to sweat.

SWEDEN, one of the most northerly kingdoms of Europe, lying between Lat. 55. 20. and 69. 30. north, and between 12° and 32° east from London. On the south it is bounded by the Baltic, on the north by Danish Lapland, on the east by Muscovy, and on the west by the mountains of Norway, being 800 miles in length and 350 in breadth.

The early history of Sweden is no less involved in fables than that of most other nations. Some historians have pretended to give regular catalogues of the princes who reigned in Sweden in very early times; but they differ so much among themselves, that no credit can be given to them. However, all agree that ancient Scandinavia was first governed by judges elected for a certain time by the voice of the people. Among these temporary princes the country

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was divided, until, in the year of the world 2054, according to some, or 1951, according to others, Eric, or, if we believe Puffendorf, Suenon was raised to the supreme power, with the prerogatives of all the temporary magistrates united in his person for life, or until his conduct should merit deposition.

From this very early period till the year 1366 of the Christian era, the histories of Sweden present us with nothing but what is common to all nations in their early periods, viz. the endless combats and massacres of barbarians, tending to no other purpose than the effusion of blood. At the time just mentioned, however, Albert of Mecklenburg, having concluded a peace between Sweden and Denmark, which two kingdoms had been at violent war for some time before, was proclaimed king of Sweden. The peace was of short duration, being broken in 1368; on which Albert entered into an offensive and defensive league with the earl of Holstein, the Jutland nobility, the dukes of Selfwick, Mecklenburg, and the Hanse-towns, against the kings of Denmark and Norway. Albert proved very successful against Waldemar king of Denmark at that time, driving him entirely out of his dominions; but he himself was defeated by the king of Norway, who laid siege to his capital. Soon after this, a new treaty of peace was concluded, by which Albert was allowed to enjoy the crown of Sweden in peace. However, having formed a design of rendering himself absolute, he fell under the displeasure of his subjects, and Margaret of Norway was proclaimed queen of Sweden by the malecontents. A war immediately ensued, in which Albert was defeated and taken prisoner; but the princes of Mecklenburg, the earls of Holstein, and the Hanse-towns, entered into a league in his favour, the war was so far from being extinguished by this event, that it raged with more fury than ever.

At length, in 1394, the contending parties came to an accommodation. Albert was set at liberty, on condition that he should in three years surrender to Margaret all pretensions to the city of Stockholm; and the Hanse-towns engaged to pay the sum of 60,000 marks of silver in case of Albert's breach of faith. Not long after this, Eric the son of Albert died; and he, having no other child, did not think it worth his while to contend for the kingdom of Sweden: he therefore acquiesced in the pretensions of Margaret, and passed the remainder of his days at Mecklenburg.

Margaret died in 1415, and was succeeded by Eric of Pomerania. This prince's reign was cruel and oppressive to the last degree. The people were ruined by taxes; and the Danes being every where preferred to the offices of power, committed the greatest cruelties. The consequence of this was a revolt; and Charles Canutson, grand marshal of Sweden and governor of Finland, having joined the malecontents, was declared commander in chief of their army. Eric was now formally deposed, and commenced pirate: Canutson was chosen regent: but beginning to oppress the people, and aspiring openly at the crown, the Swedes and Danes revolted; in consequence of which a revolution took place, and Christopher duke of Bavaria, nephew to Eric, was chosen king of Denmark, Sweden, and Norway, in 1442.

On the accession of the new prince, complaints against Canutson were brought from all quarters; but, through the interest of his friends, he escaped the punishment due to him; and in 1448, Christopher having died after a tyrannical reign of somewhat more than five years, he was raised to the throne at which he had so long aspired. However, the kingdoms of Denmark and Norway refused to own allegiance to him; upon which a war immediately commenced.

D d

In

Sweden.

8
The three kingdoms united under Christian king of Denmark, and proves a tyrant, and is driven out.

In 1454 peace was concluded, and Denmark for the present freed from the Swedish yoke. Neither did Canutson long enjoy even the crown of Sweden itself. Having quarrelled with the archbishop of Upsal, the latter formed such a strong party that the king could not resist him. Christian king of Denmark was called to the throne of Sweden; and in 1459 once more united the three kingdoms. He enjoyed his dignity but a short time; for having begun to oppress his subjects in an arbitrary manner, he was obliged to retire to Denmark in 1463. Katil bishop of Lincoping, who had driven out the king, took upon himself the office of regent. Next year Christian returned with a powerful army; but was defeated. The people then thought proper to recall Canutson: but he, on his first accession, having offended the warlike Bishop Katil, was by him defeated, and obliged to renounce his right to the crown. After this the kingdom was rent into factions; between whom the most cruel civil wars took place, until the year 1467, when Canutson was again recalled, and enjoyed the kingdom, though not without difficulty and opposition, till his death, which happened in 1470.

The confusion in which the Swedish affairs had been so long involved did not cease on the death of Canutson. Christian again invaded Sweden; but was defeated by Steen Sture, nephew to the late king. After this the kingdom seems to have remained in peace till the year 1487, when the Russians invaded Carelia, committing everywhere the greatest ravages. These were soon driven out; but in 1497, a rupture happening betwixt Sture and the senate, an offer was made of the Swedish crown to John king of Denmark. This prince readily accepted the offer, and was crowned accordingly; but no sooner was he seated on the throne than he became odious to the Swedes, from his partiality to the Danes. In a short time he set out for Denmark, leaving his queen, with a strong garrison, in the citadel of Stockholm. He was no sooner gone than the capital was invested; and though the queen made a noble defence, she was at last obliged to capitulate, on condition of being allowed to pass into Denmark. All the garrison were made prisoners of war, and the queen herself was confined in a monastery till the following year.

The Swedish affairs continued to be involved in the same dreadful confusion as we have already related, until the year 1520, when a great revolution was effected by Gustavus Ericson, a nobleman of the first rank, who restored the kingdom to its liberty, and laid the foundation of its future grandeur. The occasion of this great revolution was as follows: In 1518, Christian king of Denmark invaded Sweden, with a design to subdue the whole country; but being defeated with great loss by young Steen Sture, the regent at that time, he set sail for Denmark. But meeting with contrary winds, he made several descents on the Swedish coast, which he ravaged with all the fury of an incensed barbarian. The inhabitants, however, bravely defended themselves, and Christian was reduced to the utmost distress; one half of his forces having perished with hunger, and the other being in the most imminent danger by the approach of a rigorous winter. He then thought of a stratagem, which had almost proved fatal to the regent; for having invited him to a conference, at which he designed either to assassinate or take him prisoner, Sture was about to comply, had not the senate, who suspected the plot, interposed and prevented him. Christian then offered to go in person to Stockholm in order to confer with Sture, upon condition that six hostages should be sent in his room. This was accordingly done; but the wind happening then to prove favourable, he set sail for Denmark with the hostages, of whom Gustavus Ericson was one. Next year he returned; and

having drawn Sture into an ambush, the regent received a wound of which he died some time after. The kingdom being thus left without a head, matters soon came to the most desperate crisis. The army disbanded itself; and the senate, instead of taking proper measures to oppose the enemy, spent their time in idle debates. Christian in the mean time advanced into the heart of the kingdom, destroying every thing with fire and sword; but on his arrival at Stragnez, he granted a suspension of arms, to give the people time to deliberate on their situation, and to reflect that they might easily get rid of their troubles by electing him king. This they accordingly did; and Christian proved one of the most bloody tyrants that ever sat on the throne of any kingdom. Immediately after his coronation, he gave grand entertainments for three days; during which time he projected the diabolical design of extirpating at once all the Swedish nobility, and thus for ever preventing the people from revolting, by depriving them of their proper leaders. As the tyrant had signed articles, by which he promised indemnity to all who had borne arms against him, it became necessary to invent some cause of offence against those whom he intended to destroy. To accomplish his purpose, Gustavus Trolle, formerly archbishop of Upsal, but who had been degraded from that dignity, in an oration before his majesty lamented the demolition of Steckka, his place of residence, and the losses sustained by the see of Upsal, amounting to near a million of money. He then proceeded in a bitter accusation against the widow and the son-in-law of Sture the late regent, comprehending in the same accusation about 15 of the principal nobility, the whole senate, and the burghers of Stockholm. The consequence of this was, that above 60 of the principal nobility and people of first rank in Sweden were hanged up as traitors. Innumerable other cruelties were committed; part of which are owned by the Danish historians, and minutely related by those of Sweden. At last he departed for Denmark, ordering gibbets to be erected, and causing the peasants to be hanged on them for the slightest offences, all the way as he passed along; and it is related of him, that at Jencoping he caused two boys, one of seven and the other of nine years of age, to be whipped to death.

This monstrous cruelty, instead of securing him on the throne, exasperated the whole nation against him. It has already been mentioned, that Gustavus Ericson, or, as he is commonly called, *Gustavus Vasa*, was among the number of the hostages whom Christian had perfidiously carried to Denmark in 1519. Large promises had been made in order to reconcile him to Christian, and threats had been used for the same purpose, but all in vain. Secret orders were given to strangle him in prison; but the officer to whom the assassination was committed remonstrated to the king about the consequences of it, and prevailed on him to change the sentence of death into close confinement in the castle of Copenhagen. Some of the hostages perished in consequence of the rigorous treatment they met with; but Gustavus withstood all hardships. At last one Banner, a Danish nobleman, prevailed on the king to put him into his hands, in order to try whether or not he could prevail upon him to change his sentiments. The king, however, told Banner, that he must pay 6000 crowns in case the prisoner should make his escape. Banner generously assented; and having brought the noble prisoner to his fortress of Cala in Jutland, soon allowed him all the liberty he could desire, and otherwise heaped favours upon him. All this, however, could not extinguish his remembrance of the cruelties of Christian, and the desire he had of being serviceable to his country. He therefore determined to make his escape; and the liberty he enjoyed soon put him in a capacity of effecting

Sweden.
11
He treacherously carries off six hostages, of whom Gustavus Ericson is one.

12
Is chosen king, and proves a most bloody tyrant.

13
Massacres the nobility, and causes gibbets to be erected as he passes along.

14
Adventures of Gustavus Vasa or Ericson.

15
He escapes from Denmark.

10
Christian king of Denmark invades Sweden, but is defeated and driven out.

Sweden. effecting it. Having one day mounted his horse, under pretence of hunting as usual in the forest, when he got at a proper distance, he changed his dress to the habit of a peasant; and quitting his horse, he travelled for two days on foot through by-paths, and over mountains almost impassable, arriving on the third at Flensburg. Here no one was admitted without a passport; and Gustavus dreaded presenting himself to the governor or the officer upon guard, for fear of being discovered. Happily for him, it chanced to be on that season of the year when the merchants of Lower Saxony drove a considerable trade in cattle, which they purchase in Jutland. Gustavus hired himself to one of these merchants; and under favour of his disguise escaped out of the Danish territories, and arrived at Lubec.

16
Arrives at
Lubec.

Banner was no sooner acquainted with his escape, than he set out after him with the utmost diligence, found him at Lubec, and reproached him with great warmth as ungrateful and treacherous; but he was soon appeased by the arguments urged by Gustavus, and especially by the promise he made of indemnifying him in the loss of his ransom. Upon this Banner returned, giving out that he could not find his prisoner. Christian was enraged at his escape, apprehending that he might reverse all his designs in Sweden; and gave orders to Otho his general to make the strictest search, and leave no means untried to arrest him. Gustavus applied to the regency for a ship to convey him to Sweden, where he hoped he should be able to form a party against the Danes. He likewise endeavoured to draw the regency of Lubec into his measures; and reasoned with so much zeal and ability, that Nicholas Gemins, first consul, was entirely gained; but the regency could never be prevailed on to declare for a party without friends, arms, money, or credit. However, before his departure, the consul gave him assurances, that if he could raise a force sufficient to make head against the enemy in the field, he might depend on the services of the republic, and that the regency would immediately declare for him. Gustavus desired to be landed at Stockholm; but the captain of the ship, either having secret orders to the contrary, or business elsewhere, steered a different course, and put him on shore near Calmar; a city hitherto garrisoned by the troops of Christina widow of the regent. In truth, the governor held this place for his own purposes, and only waited to make the best terms he could with the Danes. When Gustavus arrived, he made himself known to him and the principal officers of the garrison, who were mostly Germans, and his fellow-soldiers in the late administrator's army. He flattered himself that his birth, his merit, and connections, would immediately procure him the command. But the mercenary band, seeing him without troops and without attendants, regarded him as a desperate person devoted to destruction, refused to embrace his proposals, and even threatened to kill or betray him, if he did not instantly quit the city.

18
He arrives
at Calmar,
but meets
with an un-
favourable
reception.

Disappointed in his expectations, Gustavus departed with great expedition; and his arrival being now publicly known, he was again forced to have recourse to his peasant's disguise to conceal him from the Danish emissaries dispersed over the country to search for him. In a waggon loaded with hay he passed through every quarter of the Danish army, and at last repaired to an old family castle in Sudermania. From hence he wrote to his friends, notifying his return to Sweden, and beseeching them to assemble all their forces in order to break through the enemy's army into Stockholm, at that time besieged; but they, too, refused to embark in so hazardous and desperate an attempt.

19
His friends
refuse to
assist him.

Gustavus next applied himself to the peasants: but they answered, that they enjoyed salt and herrings under the government of the king of Denmark; and that any attempts to bring about a revolution would be attended with certain ruin, without the prospect of bettering their condition; for peasants they were, and peasants they should remain, whoever was king. At length, after several vain attempts to throw himself into Stockholm, after that city was surrendered to the king, after the horrid massacre of the senate, and after running a thousand dangers, and undergoing hardships and fatigues hardly to be supported by human nature, he formed the resolution of trying the courage and affection of the Dalecarlians. While he was in the deepest obscurity, and plunged in almost unsurmountable adversity, he never relinquished his designs nor his hopes. The news of the massacre had, however, very near sunk him into despondency, as thereby he lost all his friends, relations, and connections, and indeed almost every prospect of safety to himself or deliverance to his country. It was this that inspired the thought of going to Dalecarlia, where he might live with more security in the high mountains and thick woods of that country, if he should fail in the attempt of exciting the inhabitants to revolt.

Attended by a peasant, to whom he was known, he travelled in disguise through Sudermania, Nericia, and Westermania, and, after a laborious and painful journey, arrived in the mountains of Dalecarlia. Scarce had he finished his journey, when he found himself deserted by his companion and guide, who carried off with him all the money he provided for his subsistence. Thus forlorn, destitute, half starved, he entered among the miners, and wrought like a slave under ground, without relinquishing his hopes of one day ascending the throne of Sweden. His whole prospect for the present was to live concealed, and gain a maintenance, until fortune should effect something in his favour: nor was it long before this happened. A woman in the mines perceived, under the habit of a peasant, that the collar of his shirt was embroidered. This circumstance excited curiosity; and the graces of his person and conversation, which had something in them to attract the notice of the meanest of the vulgar, afforded room for suspicion that he was some person of quality in disguise, forced by the tyranny of the government to seek shelter in these remote parts. The story came to the ears of a neighbouring gentleman, who immediately went to the mines to offer his protection to the unfortunate stranger; and was astonished on recognizing the features of Gustavus, whose acquaintance he had been at the university of Upsal. Touched with compassion at the deplorable situation of so distinguished a nobleman, he could scarce refrain from tears; but however had presence of mind enough not to make the discovery. At night he sent for Gustavus, made him an offer of his house, and gave him the strongest assurances of his friendship and protection. He told him, he would meet with better accommodations, and as much security as in the mines; and that, should he chance to be discovered, he would, with all his friends and vassals, take arms in his defence.

This offer was embraced by Gustavus with joy, and he remained for some time at his friend's house; but finding it impossible to induce him to take part in his designs, he quitted him, and fled to one Peterfon, a gentleman whom he had formerly known in the service. By him he was received with all the appearance of kindness; and, on the very first proposal made by Gustavus, offered to raise his vassals. He even named the lords and peasants whom he pretended to have engaged in his service; but in a very few days after, he went secretly to a Danish officer, and gave him information of what had passed. The officer immedi-

Sweden.
20
Applies in
vain to the
peasants.

21
Arrives in
Dalecarlia,
is robbed
by his guide
and obliged
to work in
the mines.

22
Is discovered
and re-
lieved.

Sweden.
23
Has a very
narrow es-
cape from
the Danes.

ately caused the house to be surrounded with soldiers, in such a manner that it seemed impossible for Gustavus to make his escape. In the interval, however, he escaped, being warned by Peterson's wife of the treachery of her husband, and by her direction fled to the house of a clergyman, her friend. By him Gustavus was received with all the respect due to his own birth and merit; and left the domestic who conducted him should follow the treacherous example of his master, he removed him to the church, and conducted him to a small closet, of which he kept the key. Having lived for some time in this manner, Gustavus began to consult with his friend concerning the most proper method of putting their schemes in execution. The priest advised him to apply directly to the peasants themselves; told him that it would be proper to spread a report, that the Danes were to enter Dalecarlia in order to establish new taxes by force of arms; and as the annual feast of all the neighbouring villages was in a few days to be held, he could not have a more favourable opportunity: at the same time he promised to engage the principal persons of the diocese in his interest.

24
His cause
espoused by
the peasants
of Dalecar-
lia.

Agreeable to this advice Gustavus set out for Mora, where the feast was to be held. He found the peasants already informed of his designs, and impatient to see him. Being already prepossessed in his favour, they were soon excited to an enthusiasm in his cause, and instantly resolved to throw off the Danish yoke. In this design they were more confirmed by their superstition; some of their old men having observed that the wind had blown from the north while Gustavus was speaking, which among them was reckoned an infallible omen of success. Gustavus did not give their ardour time to cool, but instantly led them against the governor's castle; which he took by assault, and put the garrison to the sword. This inconsiderable enterprise was attended with the most happy consequences. Great numbers of the peasants flocked to his standard; some of the gentry openly espoused his cause, and others supplied him with money. Christian was soon acquainted with what had passed; but despising such an inconsiderable enemy, he sent only a slender detachment under the command of one Soren Norby, to assist his adherents in Dalecarlia. Gustavus advanced with 5000 men, and defeated a body of Danes commanded by one Meleen; but he was strenuously opposed by the archbishop of Upsal, who raised numerous forces for king Christian. The fortune of Gustavus, however, still prevailed, and the archbishop was defeated with great loss. Gustavus then laid siege to Stockholm; but his force being too inconsiderable for such an undertaking, he was forced to abandon it with loss.

25
The Danes
defeated.

This check did not prove in any considerable degree detrimental to the affairs of Gustavus; the peasants from all parts of the kingdom flocked to his camp, and he was joined by a reinforcement from Lubec. Christian, unable to suppress the revolt, wreaked his vengeance on the mother and sisters of Gustavus, whom he put to death with the most excruciating torments. Several other Swedish ladies he caused to be thrown into the sea, after having imposed on them the inhuman task of making the sacks into which they were to be inclosed. His barbarities served only to make his enemies more resolute. Gustavus having assembled the states at Wadstena, he was unanimously chosen regent, the diet taking an oath of fidelity to him, and promising to assist him to the utmost. Having thus obtained the sanction of legal authority, he pursued his advantages against the Danes. A body of troops appointed to throw succours into Stockholm were totally cut in pieces; and the regent sending some troops into Finland, struck the Danes there with such terror, that the archbishop of Upsal, together with Slahog

26
Horrid
cruelty of
King Chri-
stian.

27
Success of
Gustavus.

and Baldenacker the Danish governors, fled to Denmark. Christian received them but very coldly, apprehending that their flight might be prejudicial to his affairs; and in a short time the two governors were put to death, that the king might have an opportunity of charging them with being guilty of the cruelties which they had committed by his order. He then sent express orders to all his governors and officers in Finland and Sweden to massacre the Swedish gentry without distinction. The Swedes made reprisals by massacring all the Danes they could find; so that the whole country was filled with bloodshed and slaughter.

In the mean time Gustavus had laid siege to the towns of Calmar, Abo, and Stockholm; but Norby found means to oblige him to raise all of them with great loss. Gustavus, in revenge, laid siege to the capital a third time, and petitioned the regency of Lubec for a squadron of ships and other succours for carrying on the siege. This was complied with, but on very hard conditions, viz, that Gustavus should oblige himself, in the name of the states, to pay 60,000 merks of silver as the expence of the armament; that, until the kingdom should be in a condition to pay that sum, the Lubec merchants trading to Sweden should be exempted from all duties on imports or exports; that all other nations should be prohibited from trading with Sweden, and that such traffic should be deemed illicit; that Gustavus should neither conclude a peace, nor even agree to a truce, with Denmark, without the concurrence of the regency of Lubec; and that in case the republic should be attacked by Christian, he should enter Denmark at the head of 20,000 men. Upon these hard terms did Gustavus obtain assistance from the regency of Lubec; nor did his dear-bought allies prove very faithful. They did not indeed go over to the enemy; but in a sea-fight, where the Danes were entirely in the power of their enemies, they suffered them to escape, when their whole force might have been entirely destroyed. This treachery had well nigh ruined the affairs of Gustavus; for Norby was now making preparations effectually to relieve Stockholm; in which he would probably have succeeded: but at this critical period news arrived that the Danes had unanimously revolted, and driven Christian from the throne; and that the king had retired into Germany, in hopes of being restored by the arms of his brother-in-law the emperor. On hearing this news, Norby retired with his whole fleet to the island of Gothland, leaving but a slender garrison in Calmar. Gustavus did not fail to improve this opportunity to his own advantage, and quickly made himself master of Calmar. Mean time Stockholm continued closely invested; but Gustavus thought proper to protract the siege until he should get himself elected king. Having for this purpose called a general diet, the first step was to fill up the vacancy in the senate occasioned by the massacres of Christian. Gustavus had the address to get such nominated as were in his interest; and of consequence the assembly was no sooner met, than a speech was made, containing the highest encomiums on Gustavus, setting forth in the strongest light the many eminent services he had done for his country, and concluding that the states would show themselves equally ungrateful and blind to their own interest if they did not immediately elect him king. This proposal was acceded to by such tumultuous acclamations that it was impossible to collect the votes; so that Gustavus himself acknowledged, that their affection exceeded his merit, and was more agreeable to him than the effects of their gratitude. He was urged to have the ceremony of his coronation immediately performed: but the king having some designs on the clergy, did not think proper to comply with their request, as he would have been obliged to take an oath to preserve them

Sweden.

28
He is cho-
sen king of
Sweden.

²⁹ Sweden. in their rights and privileges.—Indeed he had not been long seated on the throne before he incurred the displeasure of that body; for having large arrears due to the army, with several other incumbrances, Gustavus found it necessary to raise large contributions on the clergy. On this he was accused of avarice and heresy before the pope's nuncio. Gustavus took the proper methods for defending himself against these accusations; and in a short time after showed a great partiality for the doctrines of Luther, which by this time had been preached and received by many people in Sweden. This embroiled him more than ever with the ecclesiastics; and it soon appeared, that either Gustavus must resign his throne, or the clergy some part of the power they had assumed. Matters were driven to extremities by the king's allowing the scriptures to be translated into the Swedish language. In 1526, the king, finding them entering into a combination against the reformists, went to Upsal, and publicly declared his resolution of reducing the number of oppressive and idle monks and priests, who, under pretence of religion, fattened on the spoils of the industrious people. At last, taking advantage of the war between the pope and Charles V. of Spain, he declared himself to be of the reformed religion, and established it throughout his dominions; and at the same time, to humble the arrogance of the ecclesiastics, he gave the senators the precedence of them, and in many other respects degraded them from the dignities they formerly enjoyed. For some time the states hesitated at supporting the king in his work of reformation; inasmuch, that at last he threatened to resign the kingdom, which, he said, was doomed to perpetual slavery either to its temporal or spiritual tyrants. On this the states came into his measures, and retrenched the privileges of the ecclesiastics in the manner he proposed. Several disturbances, however, ensued. An impostor, who pretended to be of the family of Sture the former regent, having claimed the throne, the Dalecarlians revolted in his favour; but on the approach of a powerful army sent by Gustavus, they submitted to his terms. Soon after, Lutheran professors were established in every diocese; upon which a new rebellion ensued. At the head of this was Thure Johanfon, who had married the king's sister. Several of the nobility joined him; and the king of Denmark also acceded to their cause, thinking, by means of these disturbances, to reunite the three kingdoms of Sweden, Denmark, and Norway, as they had formerly been. But Gustavus prevailed, and the rebels were obliged to take refuge in Denmark. A fresh accident, however, had like to have embroiled matters worse than before. The subsidy granted to the regency of Lubec was still due; and for the payment of it the states granted to the king all the useless bells of the churches and monasteries. The people were shocked at the sacrilege; and the Dalecarlians again betook themselves to arms. Intimidated, however, by the courage and vigorous conduct of the king, they again submitted, and were taken into favour. But tranquillity was not yet restored. Christian having established a powerful interest in Norway, once more made an attempt to recover his kingdoms, and was joined by the Dalecarlians; but being defeated by the Swedish forces, he was forced to return to Norway, where, being obliged to capitulate with the Danish generals, he was kept prisoner all his life.

³⁰ Renounces the Popish religion and establishes Protestantism. In 1542, Gustavus having happily extricated himself out of all his troubles, prevailed on the states to make the crown hereditary in his family; after which he applied himself to the encouragement of learning and commerce. A treaty was set on foot for a marriage between his eldest son Eric and Elizabeth queen of England. The prince's brother, duke John, went over to England, and resided for some

³¹ Disturbances in consequence of this. time at the court of London with great splendour. He returned, full of expectations of success; but bringing with him no sort of proofs in writing, his father soon perceived that he had been the dupe of Elizabeth's superior policy. However, at last he allowed Prince Eric to go in person to England; but before he could embark, the death of Gustavus made him lay aside all thoughts of the voyage and marriage.

³² Unsuccessful attempt of Christian. Gustavus Vasa died in 1560, and was succeeded by his son Eric XIV. The new king was a man possessed of all the exterior ornaments which give an air of dignity to the person; but he had neither the prudence nor the penetration of his father. He created the first nobility that were ever known in Sweden; which he had no sooner done than he quarrelled with them, by passing some acts which they thought derogatory to their honour and dignity. The whole course of his reign was disturbed by wars with Denmark, and disputes with his own subjects. In the former he was unfortunate, and towards the latter he behaved with the greatest cruelty. At last, by the torments of his own conscience, it is said, he run mad. He afterwards recovered his senses, but was thereupon dethroned by his brothers; of whom Duke John, who had been hitherto kept prisoner by Eric, succeeded him in the kingdom.

³³ The crown becomes hereditary. This revolution took place in the year 1568, but with no great advantage to Sweden. Disputes about religion between the king and his brothers, and wars with Muscovy, threw matters into the utmost confusion. At last prince Sigismund, the king's son, was chosen king of Poland, which proved the source of much trouble to the kingdom. He was elected on the following conditions, viz. That there should be a perpetual peace between the states of Poland and Sweden; that, on the death of his father, prince Sigismund should succeed to the throne of Sweden; that, on urgent occasions, he might, with the consent of the states, return to Sweden; that he should maintain, at his own expence, a fleet for the service of Poland; that he should cancel a debt which had been long due from the crown of Poland to Sweden; that, with the consent of the states, he should build five fortresses on the frontiers of Poland; that he should have liberty to introduce foreign soldiers into the kingdom, provided he maintained them at his own expence; that he should not make use of Swedish counsellors in Poland; that he should have his body-guard entirely of Poles and Lithuanians; and that he should annex to Poland that part of Livonia now subject to Sweden. In 1590 king John died; and as Sigismund was at a distance, every thing fell into the utmost confusion; the treasury was plundered, and the wardrobe quite spoiled, before even duke Charles could come to Stockholm to take the administration into his hands until king Sigismund should return. This, however, was far from being the greatest disaster which befel the nation at this time. It was known that the king had embraced the Popish religion, and it was with good reason suspected that he would attempt to restore it upon his arrival in Sweden. Sigismund also was obliged, on leaving Poland, to promise that he would stay no longer in Sweden than was necessary to regulate his affairs. These circumstances served to alienate the minds of the Swedes from their sovereign even before they saw him; and the universal dissatisfaction was increased, by seeing him attended, on his arrival in Sweden in 1593, by Malaspina the pope's nuncio, to whom he made a present of 30,000 ducats to defray the expences of his journey to Sweden.

³⁴ Unsuccessful negotiation for a marriage with Queen Elizabeth. What the people had foreseen was too well verified: the king refused to confirm the Protestants in their religious privileges, and showed such partiality on all occasions to the Papists, that a party was formed against him; at the head of

³⁵ Gustavus dies, and is succeeded by Eric a weak and imprudent prince. Eric deposed, and succeeded by his brother John. Prince Sigismund chosen king of Poland. Succeeds to the crown of Sweden.

³⁶ A party formed against him.

³⁷ A party formed against him.

³⁸ A party formed against him.

Sweden.

of which was duke Charles his uncle. Remonstrances, accompanied with threats, took place on both sides; and at an interview between the king and Charles, the dispute would have ended in blows, had they not been parted by some of the nobility. This, however, made such an impression upon Sigismund, that he was apparently reconciled to his brother, and promised to comply with the inclinations of the people in every respect, though without any inclination to perform what he had promised. The agreement, indeed, was scarce made, before Sigismund conceived the horrid design of murdering his uncle at the Italian comedy acted the night after his coronation. The duke, however, having notice of the plot, found means to avoid it. This enraged the king so much, that he resolved to accomplish his designs by force; and therefore commanded a Polish army to march towards the frontiers of Sweden, where they committed all the ravages that could be expected from an enraged and cruel enemy. Complaints were made by the Protestant clergy to the senate: but no other reply was made them, than that they should abstain from these bitter invectives and reproaches, which had provoked the Catholics, until the king's departure; at which time they would be at more liberty.

40
Forms a design of murdering his uncle.

In 1595 Sigismund set sail for Dantzic, leaving the administration in the hands of duke Charles. The consequence of this was, that the dissensions which had already taken place being continually increased by the obstinacy of the king, duke Charles assumed the sovereign power; and in 1604 Sigismund was formally deposed, and his uncle Charles IX. raised to the throne. He proved a wise and brave prince, restoring the tranquillity of the kingdom, and carrying on a war with vigour against Poland and Denmark. He died in 1611, leaving the kingdom to his son, the celebrated Gustavus Adolphus.

41
Sigismund deposed, and is succeeded by Charles IX.

Though Charles IX. by his wise and vigorous conduct had in a great measure retrieved the affairs of Sweden, they were still in a very disagreeable situation. The finances of the kingdom were entirely drained by a series of wars and revolutions; powerful armies were preparing in Denmark, Poland, and Russia, while the Swedish troops were not only inferior in number to their enemies, but the government was destitute of resources for their payment.

42
State of Sweden on the accession of Gustavus Adolphus.

Though the Swedish law required that the prince should have attained his 18th year before he was of age, yet such striking marks of the great qualities of Gustavus appeared, that he was allowed by the states to take upon him the administration even before this early period. His first act was to resume all the crown-grants, that he might be the better able to carry on the wars in which he was unavoidably engaged; and to fill all places, both civil and military, with persons of merit. At the head of domestic and foreign affairs was placed chancellor Oxenstiern, a person every way equal to the important trust, and the choosing of whom impressed mankind with the highest opinion of the young monarch's penetration and capacity.

43
He is allowed to assume the administration while yet a minor.

Soon after his accession, Gustavus received an embassy from James I. of Britain, exhorting him to make peace with his neighbours. This was seconded by another from Holland. But as the king perceived that the Danish monarch intended to take every opportunity of crushing him, he resolved to act with such vigour, as might convince him that he was not easily to be overcome. Accordingly he broke into Denmark with three different armies at once; and though the enemy's superiority at sea gave them great advantages, and the number of the king's enemies distracted his attention, he carried on the war with such spirit, that in 1613 a peace was concluded upon good terms. This war

44
He invades Denmark, and obliges the king to conclude a peace.

being finished, the king applied himself to civil polity, and made some reformations in the laws of Sweden. In 1615, hostilities were commenced against Russia, on account of the refusal of that court to restore some money which had been formerly lent them. The king entered Ingria, took Kexholm by storm, and was laying siege to Plescow, when, by the mediation of James I. peace was concluded, on condition of the Russians repaying the money, and yielding to Sweden some part of their territory. In this and the former war, notwithstanding the shortness of their duration, Gustavus learned the rudiments of the military art for which he soon became so famous. He is said, indeed, to have caught every opportunity of improvement with a quickness of understanding seemingly more than human. In one campaign, he not only learned, but improved, all the military maxims of La Gardie, a celebrated general, brought the Swedish army in general to a more steady and regular discipline than had formerly been exercised, and formed and seasoned an invincible body of Finlanders, who had afterwards a very considerable share in the victories of the Swedes.

45
Russia invaded with success.

46
Extraordinary military genius of the king.

Peace was no sooner concluded with Russia, than Gustavus was crowned with great solemnity at Upsal. Soon after this, Gustavus ordered his general La Gardie to acquaint the Polish commander Codekowitz, that as the truce between the two kingdoms, which had been concluded for two years, was now expired, he desired to be certainly informed whether he was to expect peace or war from his master. In the mean time, having borrowed money of the Dutch for the redemption of a town from Denmark, he had an interview on the frontiers with Christian the king of that country. At this interview, the two monarchs conceived the utmost esteem and friendship for each other; and Gustavus obtained a promise, that Christian would not assist Sigismund in any designs he might have against Sweden. In the mean time, receiving no satisfactory answer from Poland, Gustavus began to prepare for war. Sigismund entered into a negotiation, and made some pretended concessions, with a view to seize Gustavus by treachery; but the latter having intimation of his design, the whole negotiation was changed into reproaches and threats on the part of Gustavus.

47
Has a friendly interview with the king of Denmark, and prepares for war with Poland.

Immediately after this, Gustavus made a tour in disguise through Germany, and married Eleonora the daughter of the elector of Brandenburg. He then resolved to enter heartily into a war with Poland; and with this view set sail for Riga with a great fleet, which carried 20,000 men. The place was well fortified, and defended by a body of veterans enthusiastically attached to Sigismund. A dreadful bombardment ensued; the streets were raked by the cannon, and the houses laid in ashes by the bombs; the moat was filled up, one of the half-moons taken by storm, and the strong fortress of Dunamund was reduced. The cannon having now effected a breach in another part of the walls, Gustavus resolved to make a general assault. For this purpose a flying bridge over the moat was contrived by his majesty; for though the ditch was filled with fascines and rubbish, it still contained too much water to admit the passage of a large body of men. The soldiers, however, crowded on to the attack with so much impetuosity, that the bridge gave way, and the attempt proved unsuccessful. Next day the Swedes were repulsed in attempting to storm another half-moon; and the king was obliged to proceed more slowly. By the middle of September, at which time the town had been invested for six weeks, two bridges were thrown over the river together with a strong boom, while the Swedes had formed their mines under the ditch. The garrison being now reduced to extremity, were obliged to capitulate;

48
Marries Eleonora daughter of the elector of Brandenburg.

49
Riga besieged and taken.

Sweden. capitulate; and Gustavus treated the inhabitants with great clemency.

50 The Poles defeated and several places taken. After the reduction of Riga, the Swedish monarch entered Courland, where he reduced Mittau; but ceded it again on the conclusion of a truce for one year. Sigismund, however, no sooner had time to recover himself, than he began to form new enterprises against the Swedes in Prussia; but Gustavus setting sail with his whole fleet for Dantzic, where the king of Poland then resided, so broke his measures, that he was obliged to prolong the truce for another year. Sigismund, however, was not yet apprised of the danger he was in, and refused to listen to any terms of accommodation: upon which Gustavus entering Livonia, defeated the Polish general, and took Derpt, Hockenhausen, and several other places of less importance; after which, entering Lithuania, he took the city of Birsen.

51 The Poles again defeated, and a great number of towns reduced by Gustavus. Notwithstanding this success, Gustavus proposed peace on the same equitable terms as before; but Sigismund was still infatuated with the hopes that, by means of the emperor of Germany, he should be able to conquer Sweden. Gustavus finding him inflexible, resolved to push his good fortune. His generals Horn and Thurn defeated the Poles in Semigallia. Gustavus himself with 150 ships set sail for Prussia, where he landed at Pillaw. This place was immediately delivered up to him; as were also Braunsberck, Frawenberg, Elbing, Marienberg, Mew, Dirschau, Stum, Christburg, &c. Sigismund, alarmed at the great successes of Gustavus, sent a body of forces to oppose him, and to prevent Dantzic from falling into his hands. In this he was attended with as bad success as before. His troops were defeated before Marienberg, Mew, and Dirschau; and in May 1627, Gustavus arrived with fresh forces before Dantzic, which he would probably have carried, had he not been wounded in the belly by a cannon-shot. The Poles in the mean time recovered Mew; and the States of Holland sent ambassadors to mediate a peace between the two crowns. Sigismund, however, depending upon the assistance of the emperor of Germany and king of Spain, determined to hearken to no terms, and resolved to make a winter-campaign; but Gustavus was so well intrenched, and all his forts were so strongly garrisoned, that the utmost efforts of the Poles were to no purpose (A). The city of Dantzic in the mean time made such a desperate resistance as greatly irritated Gustavus. In a sea-engagement the Swedish fleet

52 The Poles defeated a third time. defeated that of the enemy; after which Gustavus, having blocked up the harbour with his fleet, pushed his advances on the land-side with incredible vigour. He made a surprising march over a morass 15 miles broad, assisted by bridges of a peculiar construction, over which he carried a species of light cannon invented by himself. By this unexpected manœuvre he got the command of the city in such a manner, that the garrison were on the point of surrendering, when, by a sudden swell of the Vistula, the Swedish works were ruined, and the king was obliged to raise the siege. In other respects, however, the affairs of Gustavus went on with their usual good fortune. His general Wrangel defeated the Poles before Brodnitz, of whom 3000 were killed, and 1000 taken prisoners, with five pieces of cannon

53 The Poles defeated by sea, and Dantzic invested. and 2000 waggons loaden with provisions. At Stum the king gained another and more considerable victory in person. The emperor had sent 5000 foot and 2000 horse under Arnheim, who joined the main army commanded by the Polish general Coniecpolski, in order to attack the Swedish army encamped at Quidzin. The enemy were so much superior in number, that the friends of Gustavus represented to him the imminent danger of attacking them. But the king being determined, the engagement began. The Swedish cavalry charged with such impetuosity, contrary to their sovereign's express order, that they were almost surrounded by the enemy; but Gustavus, coming up to their assistance, pushed the enemy's infantry with so much vigour, that they gave way, and retreated to a bridge they had thrown over the Werder. But here they were disappointed; for the Swedes had already taken possession of the bridge. On this a new action ensued more bloody than the former, in which the king was exposed to great danger, and thrice narrowly escaped being taken prisoner; but at last the Poles were totally defeated, with the loss of a great many men, 22 pair of colours, five standards, and several other military trophies. The slaughter of the German auxiliaries was so great, that Arnheim scarce carried off one half of the troops he brought into the field. This defeat did not hinder the Polish general from attempting the siege of Stum; but here again he was attended by his usual bad fortune. The garrison sallied out, and he was defeated with the loss of 4000 men. The blame of this misfortune was laid upon

54 The king obliged by an inundation of the Vistula to raise the siege. Arnheim; who was recalled, and succeeded by Henry of Saxe Lawenburg and Philip count Mansfeldt. The change of general officers, however, produced no good consequences to the Poles; a famine and plague raged in their camp, so that they were at last obliged to consent to a truce for six years, to expire in the month of June 1635. The conditions were, that Gustavus should restore to Sigismund the towns of Brodnitz, Stum, and Dirschau; that Marienberg should remain sequestered in the hands of the elector of Brandenburg, to be restored again to Sweden in case a peace was not concluded at the end of the six years. Gustavus, on his side, kept the port and citadel of Memel, the harbour of Pillau, the town of Elbing, Brunsberg, and all that he had conquered in Livonia.

Sweden. 55 The Poles and Germans defeated with great slaughter in two engagements. Gustavus having thus brought the war with Poland to an honourable conclusion, began to think of resenting the conduct of the emperor in assisting his enemies and oppressing the Protestant states. Before embarking in such an important undertaking, it was necessary that he should consult the diet. In this the propriety of engaging in a war with Germany was warmly debated; but, after much altercation, Gustavus in a very noble speech determined the matter, and set forth in such strong terms the virtuous motives by which he was actuated, that the whole assembly wept, and every thing was granted which he could require. It was not difficult for Gustavus to begin his expedition. His troops amounted to 60,000 men, hardened by a succession of severe campaigns in Russia, Finland, Livonia, and Prussia. His fleet exceeded 70 sail, carrying from 20 to 40 guns, and manned with 6000 mariners. Embarking his

57 Gustavus resolves on a war with the emperor.

(A) In this campaign the practice of duelling became so prevalent in the Swedish army, as to engage the king's attention, and to oblige him to suppress it by very rigorous edicts. Soon after these were passed, a quarrel arose between two general officers, who asked his majesty's permission to decide their difference by the laws of honour. The king consented, but wished to be a spectator of their courage. He went to the place appointed, attended by a body of guards: and having ordered the executioner to be called, "Now gentlemen, said he to the officers, fight until one dies;" adding to the executioner, "Do you immediately cut off the head of the other." On this the quarrel was dropped, and no more challenges were heard of in the camp.

Sweden. his troops, he landed at Usedom on the 24th of June 1630, the Imperialists having evacuated all the fortresses they possessed there; and the isle of Rugen had been before reduced by general Lesly, in order to secure a retreat if fortune should prove unfavourable. Passing the frith, Gustavus stormed Wolgast and another strong fortress in the neighbourhood, leaving general Bannier with a garrison for the defence of these conquests. He then proceeded to Stetin; which was no sooner invested than it consented to receive a Swedish garrison, and the king persuaded the duke of Pomerania to enter into an alliance with him. In consequence of this the Swedish troops were received into several towns of Pomerania; and the most bitter enmity took place between the Imperialists and Pomeranians, each refusing the other quarter.

These successes of Gustavus struck the empire with consternation; for being already overwhelmed with civil dissensions, they were in no condition to resist so impetuous an enemy. At this time also the Imperialists were without a general, the command of the army being disputed by a number of candidates of very unequal merit; but at last count Tilly was fixed upon as the most proper person, and invested with the dignity of Veldt Marischal. In the mean time the king being reinforced by a considerable body of troops in Finland and Livonia under the conduct of Gustavus Horn, defeated the Imperialists before Griffenhagen; taking the place soon after by assault. By this and some other conquests he opened a passage into Lusatia and Silesia; but in the mean time count Tilly cut off 2000 Swedes at New Brandenburg, owing to the obstinacy of their commander Kniphausen, who had orders to evacuate the place and join the main army. This advantage, however, was soon overbalanced by the conquest of Franckfort on the Oder, which Gustavus took by assault, making the whole garrison prisoners. Thus he commanded the rivers Elbe and Oder on both sides, and had a fair passage not only to the countries already mentioned, but also to Saxony and the hereditary dominions of the house of Austria. Soon after this, Gustavus laid siege to Landsberg, which he took by assault; though the number of soldiers he had with him was so inconsiderable, that he had thoughts of sending to the main army for a reinforcement before the prisoners should march out, being apprehensive that they might give him battle in the open field, though they could not defend themselves behind walls.

About this time the Protestant princes held a diet at Leipzig; to which Gustavus sent deputies, and conducted his negotiations with such address, as tended greatly to promote his interests. Immediately after this he reduced Gripswald, and with it all Pomerania. Then marching to Gustrow, he restored the dukes of Mecklenburg to their dominions. Here the Imperialists had tyrannized in such a manner that Gustavus was received as the deliverer of the people; and the ceremony of the duke's inauguration was in a short time performed with great solemnity.

All this time count Tilly was employed in the siege of Magdeburg; but now, being alarmed at the repeated successes of the Swedes, he left Pappenheim with part of the army before that city, while he marched with the rest into Thuringia, to attack the landgrave of Hesse-Cassel and the elector of Saxony. After a most obstinate defence, Magdeburg fell into the hands of Pappenheim, where he committed all imaginable cruelties. Gustavus formed a plan of recovering the city; but was obliged to abandon it, by Pappenheim's throwing himself into the place with his whole army, and by the progress which Tilly was making in Thuringia. Relinquishing this enterprise, therefore, he ordered Bannier to attack Havelsburg; which was done

with such resolution, that the place was forced in a few hours, and all the garrison made prisoners. Werben was next obliged to submit after an obstinate conflict, in which many fell on both sides.—These successes obliged count Tilly to attempt in person to check the progress of the Swedes. He detached the vanguard of his army, composed of the flower of the Imperial cavalry, within a few miles of the Swedish camp. An action ensued, in which Bernstein the Imperial general was defeated and killed, with 1500 of his men. Gustavus, after this advantage, placed himself in a situation so much superior to his enemies, that count Tilly was fired with indignation, and marched up to the Swedish lines to give him battle. Gustavus kept within his works, and Tilly attacked his camp, though almost impregnablely fortified, keeping up a most terrible fire from a battery of 32 pieces of cannon; which, however, produced no other effect, than obliging the Swedish monarch to draw up his army behind the walls of Werben. Tilly had placed his chief hopes in being able to nail up the enemy's cannon, or set fire to their camp in divers quarters; after which he proposed making his grand attack. With this view he bribed some prisoners; but they betrayed him, and told his design to Gustavus. The king ordered fires to be lighted in different parts of his camp, and his soldiers to imitate the noise of a tumultuous disorderly rabble. This had the desired effect. The count led his army to the breach made by the cannon; where he was received with such a volley of grape shot as cut off the first line, and put the whole body in disorder, so that they could never be brought back to the charge. In this confusion the Imperial army was attacked by Bauditzen, and, after an obstinate conflict, obliged to quit the field.

Soon after this action the queen arrived at the camp with a reinforcement of 8000 men; at the same time a treaty was concluded with Charles I. of England, by which that monarch allowed the marquis of Hamilton to raise 6000 men for the service of Gustavus. These auxiliaries were to be conducted to the main army by a body of 4000 Swedes; and were in every thing to obey the king while he was personally present, but in his absence were to be subject to the orders of the marquis. With these troops the king had resolved to make a diversion in Bremen: but the marquis finding it impossible for him to effect a junction with the Swedish army, resolved, without debarking his troops, to steer his course for the Oder, and land at Usedom. Gustavus was very much displeased at finding his project thus disconcerted; however, making the best of the present circumstances, he commanded the British troops to act on the Oder instead of the Weser. The number of this little army was magnified exceedingly by report, insomuch that count Tilly had some thoughts of marching against them with his whole force; but on the departure of the marquis for Silesia, he reinforced the army in that country with a large detachment, which was thought to contribute not a little to the defeat he soon after received.

Ever since the late action Gustavus had kept within his intrenchments, where his army was well provided with every thing. Tilly made several attempts to surprise or draw him to an engagement; but finding all his endeavours fruitless, he marched into Saxony, and laid siege to Leipzig. This precipitate measure proved highly advantageous to the Swedish monarch; as thus the elector, who had been wavering in his resolutions, was now obliged to have recourse to the Swedes, in order to preserve himself from utter destruction. A treaty offensive and defensive was immediately concluded with Gustavus: and the elector willingly promised every thing that was required of him; and among the rest, that not only the prince his son, but he himself, should

Sweden.
58
Reduces
Wolgast,
Stetin, &c.

59
Count Tilly
chosen
general by
the emperor.

60
Cuts off
2000
Swedes.

61
Franckfort
and Landsberg
taken
by Gustavus.

62
He reduces
Pomerania,
and restores
the dukes of
Mecklenburg.

63
Magdeburg
taken by
the Imperialists,
and the inhabitants
cruelly used.

Sweden.
64
Havelsburg
and Werben re-

65
Count Tilly
defeated
by Gustavus.

66
A body of
British soldiers
comes to the assistance
of the Swedes.

Sweden. should reside in the Swedish camp, and engage his life and fortune in the common cause. Tilly, in the mean time, carried fire and sword into the unhappy electorate. At the head of an army of 44,000 veterans, he summoned the city of Leipzig to surrender; denouncing the same vengeance against it as had been executed on Magdeburg, in case of a refusal. By this the governor was so much intimidated, that he instantly submitted; and also surrendered the castle of Passenberg, which was in a condition to have stood out till the arrival of the Swedish army. The elector, enraged at the loss of these valuable places, ordered his army to join the Swedes with all expedition, and pressed the king so warmly to engage, that at last he yielded to his desire. On the 7th of September 1631, Gustavus led out his army in the most beautiful order, the Swedes forming one column on the right, and the Saxons another on the left; each amounting to 15,000 men. Tilly drew up his men in one vast column, possibly with a view of surrounding the flanks of the king's army; but every officer of experience in his army, from the excellency of the Swedish disposition, prognosticated the event of the engagement. Gustavus led on the troops against that wing of the Imperialists commanded by Pappenheim, whom he drove back to such a distance, that he gained a point of the wind; by which the smoke fell upon their enemies and considerably embarrassed them, at the same time that the Swedes were got without the reach of a battery which played furiously on their flank. General Banner in the mean time cut in pieces the troops of Holstein, and mortally wounded the duke who commanded them. Pappenheim led on his troops seven times to the charge, in hopes of regaining his former situation; but was as often repulsed by the Swedes. Tilly all this while engaged with the Saxons; but having at last driven them off the field, the whole strength of the Imperial army was turned upon the Swedish left wing commanded by General Horn. The Swedes sustained the attack with the greatest firmness, until the king detached general Teuffel with the centre to assist them. The Imperialists then were no longer able to stand their ground; but gave way everywhere except in the centre, which was composed of 18 regiments of veterans accustomed to victory, and deemed invincible. They made incredible efforts to maintain the reputation they had acquired; and, though swept off in great numbers by the Swedish artillery, never shrunk or fell into confusion. Four regiments, after their officers had been killed, formed themselves, and retired to the skirt of a wood; where they were all to a man cut in pieces, without demanding quarter. Tilly retired at the head of 600 men, and escaped by the coming on of the night. Seven thousand Imperialists lay dead on the field of battle; 4000 were taken prisoners; a fine train of artillery was lost, with upwards of 100 standards, ensigns, and other military trophies.—On this occasion it was that the Scots regiment in the Swedish service first practised the method of firing in platoons; to which some ascribe the astonishment and confusion that appeared in the Imperial army. It is thought, however, that the Swedish monarch displayed greater abilities in gaining this victory than improving it afterwards; for had he marched immediately to Vienna, before his enemies had time to recover their consternation, it is supposed that the emperor would have been obliged to abandon his capital, and leave his hereditary dominions to the mercy of the conqueror. But Gustavus apprehended that Tilly might fall upon the Saxons while he was ravaging the Austrian hereditary dominions; which would have deprived him not only of an ally, but of the free quarters which the elector had promised to his troops in case of a retreat. For this and some other reasons he determined to penetrate into Franconia, where he

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reduced several places, particularly the fortress of Workburg. Tilly having collected his scattered troops, which formed an army still superior in number to that of Gustavus, marched to the relief of this place; but came too late. He then directed his march towards Rottenberg, where four regiments were cut in pieces by a Swedish detachment. After this the king reduced Hanau, Franckfort on the Maine, and Mentz; destroying a body of Spaniards, who had thrown themselves in his way to obstruct his passage.

The court of Vienna was now thrown into the utmost confusion; and sent everywhere begging assistance, and soliciting the Catholic princes to arm in defence of their religion. The emperor was most embarrassed in finding out a general capable of opposing Gustavus in the field; for the late misfortunes of count Tilly had entirely sunk his reputation. Wallestein, an old experienced officer, was made choice of; but as he had formerly been disgraced, it was apprehended that he would not accept of the command of which he had once been deprived. This objection, however, was got over; and Wallestein not only accepted of the command, but, at his own expence, augmented the army to 40,000 men.

During the whole winter the Swedish army kept the field; and before the approach of summer had reduced Crantzach, Bobenhausen, Kirchberg, Magdeburg, Gozlar, Northeim, Gottingen, and Dunderstadt; while the landgrave William made great progress in Westphalia. Gustavus Horn was repulsed before Bamberg; but soon had his revenge, by entirely destroying two regiments of Imperialists. To prevent the troops from being affected by the loss before Bamberg, the king resolved to give battle to Tilly, who was marching into Bavaria to prevent the Swedes from gaining a footing in that electorate. He pursued the Imperial general through a vast tract of country, defeated his rear-guard, and, having reduced a variety of towns and fortresses on the Danube, penetrated as far as Ulm. Advancing to the river Leck, count Tilly posted himself in a wood on the opposite side, to dispute his passage. Gustavus endeavoured to dislodge him by a regular fire from 70 pieces of cannon. The slaughter was dreadful; and Tilly himself, being wounded by a cannon-ball in the knee, died a few days before he was to have been superseded by Wallestein. The following night the Imperial army evacuated the post; part retiring to Ingoldstadt, and others to Newburg. Gustavus immediately crossed the river, and seized the towns of Rain and Newburg, which the enemy had abandoned. Augsburg next submitted; and from the inhabitants of this place Gustavus exacted an oath of fidelity, not only to himself but to the crown of Sweden. This measure gave the greatest offence to many of the Germanic body, and made them imagine that the king of Sweden had other views than the defence of the Protestant cause.

From Augsburg the Swedes advanced towards Ratisbon; but were disappointed in their design of getting possession of that city, by reason of the Bavarians having thrown a very numerous garrison into the place.—In the mean time, ambassadors arrived from Denmark, offering the mediation of that crown for obtaining a lasting peace between the contending parties. Gustavus, however, replied, that no such peace could take place till the Catholic princes thought proper to grant the Protestants full and ample security for their enjoyment of future tranquillity. But the ambassadors had no instructions to propose any thing farther, and thus the negotiation vanished. Gustavus now, resolving to retort upon themselves the cruelties which the Bavarians had inflicted on the Protestants, laid the towns of Morzbourg, Friesen, and Landshut, in ashes. The inhabitants of Munich saved themselves by submission; but as the peasants in that

E e

neigh-

Sweden. neighbourhood had collected themselves into bodies in order to murder the stragglers from the Swedish army, Gustavus burnt their houses, and defeated the forces of the elector, who had been joined by a considerable body of militia.

76 The Saxon troops defeated by Wallestein. While Gustavus was thus employed, Wallestein had assembled a vast army. He was strongly solicited by the elector of Bavaria to come to his assistance; but, in revenge of the elector's having formerly obtained the command for count Tilly in preference to himself, he drew off towards Bohemia to encounter the Saxons. Pappenheim, who commanded the Saxon forces in that place, was the enemy of Gustavus, who had formerly rallied him for his cowardice. He therefore permitted Wallestein to gain an easy victory, in hopes that his master, the elector of Saxony, a prince entirely devoted to his pleasures, might be induced to relinquish the friendship of such a restless and warlike ally as Gustavus; and indeed he used all the eloquence of which he was master to detach him from the Swedish cause. Several advantages, in the mean time, were gained by the Imperialists. Pappenheim defeated the archbishop of Bremen's cavalry at Werden; and three Swedish regiments were cut off near Kadingen. Pappenheim, however, was forced to retire, and withdraw his forces from Stade; of which the Swedes took possession. Wallestein and the elector of Bavaria, who had now joined their forces, threatened Gustavus with greatly superior numbers. At last, however, the king, being reinforced with 15,000 men, no longer declined the engagement; but Wallestein was too wise to trust the fate of the empire to a single engagement against such an enemy as the king of Sweden. Gustavus attacked his camp, but was repulsed with the loss of 2000 men; which caused a general murmuring and discontent against his rashness. Several other misfortunes happened to the Swedes; and at last, after various manœuvres, Wallestein bent his course towards Misnia, in order to oblige the elector of Saxony to declare against the Swedes, and to draw them out of Bavaria. Gustavus, notwithstanding the inconstancy of Augustus, immediately set out to assist him. With incredible diligence he marched to Misnia, where the Imperialists were assembling their whole strength. Hearing that the enemy were encamped at Wessels, and that Pappenheim had been detached with a strong corps, Gustavus resolved to engage them before they could effect a junction. With this view he marched to Lutzen, where he attacked Wallestein with incredible fury. The Swedish infantry broke the Imperialists in spite of their utmost efforts, and took all their artillery. The cavalry not being able to pass the river so expeditiously as the king thought necessary, he led the way, attended only by the regiment of Smaaland and the duke of Saxe-Lauenburg. Here, after charging impetuously, he was killed, as Puffendorff alleges, by the treachery of the duke; who, being corrupted by the emperor, shot him in the back during the heat of the action. The news of his death was in an instant spread over both armies. The courage of the Imperialists revived, and they now made themselves sure of victory. But the Swedes, eager to revenge the death of their beloved monarch, charged with such fury that nothing could resist them. The Imperialists were defeated a second time, just as Pappenheim, with his fresh corps, came up to their assistance. On this the battle was renewed, but the Swedes were still irresistible. Pappenheim was mortally wounded, and his army finally routed, with the loss of 9000 killed in the field and in the pursuit.

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80 The Imperialists totally defeated. The victory of Lutzen proved more unfortunate to Sweden than the greatest defeat. The crown devolved upon Christina, an infant of six years old; the nation was involved in an expensive foreign war, without any person equal

to the arduous task of commanding the armies, or regulating domestic affairs, as Gustavus had done. However, Christina the daughter of Gustavus was immediately proclaimed queen. The regency devolved on the grand bailiff, the marischal, the high-admiral, the chancellor, and the treasurer of the crown. Oxenstiern was invested with the chief management of affairs, and conducted himself with the greatest prudence. He was greatly embarrassed indeed by the divisions among the Protestant princes, which became more violent after the death of Gustavus; but, in spite of all difficulties, he went on pursuing the interest of his country, and planning the means of retaining the Swedish conquests. Matters went on pretty successfully till the year 1634, when, through the rashness of the Swedish soldiers, they were defeated at Nordlingen, with the loss of 6000 men killed on the spot, a number of prisoners, and 130 standards, with other military trophies, taken by the enemy. Oxenstiern's constancy was shaken by this dreadful blow; but he applied himself diligently to repair the loss, by recruiting the army, and rendering the allies faithful. The latter proved the most difficult task. The death of Gustavus, and the defeat at Nordlingen, had thrown them into despair; and every one was desirous of making the best terms he could with the emperor. The Saxons not only renounced their alliance with Sweden, but openly commenced war against it; and though the regency would gladly have consented to an honourable peace, the enemy were now too much flushed with success to grant it. Oxenstiern had no other resource than an alliance with France, and the bravery of his generals. In 1635, he went in person to the court of Louis, and concluded a treaty; which, however, answered no purpose, as it was never observed. The enemy, in the mean time, pushed their good fortune. They surprised Philippsburg, where the French had laid up vast magazines; and reduced Spire, Augsburg, Treves, Wurzburg, Cobourg, and some other places. To complete the misfortunes of Sweden, it was expected that the Poles would immediately invade Prussia. To prevent this, La Gardie was dispatched thither with a powerful army; but as it was impossible to resist so many enemies at once, the chancellor purchased the friendship of Poland for 26 years by ceding that duchy to the republic. Thus he got rid of a powerful enemy; and the Swedish affairs began to revive by a victory which general Bannier gained over the Saxons, in consequence of which they were driven beyond the Elbe.

Early in the spring of 1636, the Saxons made some motions as if they intended to cut off Bannier's communication with Pomerania. This he prevented by a stratagem; defeated a body of the enemy; and obliged the Saxons to retire. Soon after this he drove them out of their winter-quarters with considerable loss; at which time also a considerable body of Imperialists who came to their assistance were dispersed. In Westphalia general Kniphausen beat the Imperialists with the loss of 1500 men, but he himself was killed in the pursuit, and his army obliged to repass the Weser. Some advantages were also gained in the neighbourhood of Minden by General Lesly, who had assembled a considerable army. In Alsace, Bernard duke of Saxe-Weymar defeated count Gallas the Imperial general, and dispersed his army. But when every thing seemed thus successful for the Swedes, the city of Magdeburg, contrary to the expectation of every body, surrendered for want of powder, which the garrison had wantonly consumed. The Saxons also made some conquests on the Elbe, which obliged Bannier to recall general Lesly from Westphalia to march against them. The Saxons fixed on a most convenient situation, whence they hoped to destroy the Swedish army without coming to a battle. But Bannier, resolving to hazard every

Sweden.

82 The Swedes receive a great overthrow at Nordlingen

83 The Saxons declare a-gainst Sweden.

84 Successes of the Imperialists.

85 The Saxons defeated by general Bannier.

86 The Imperialists defeated by Kniphausen

87 And by the duke of Saxe-Weymar.

Sweden. every thing rather than suffer his army to be wasted by famine, advanced towards Perleberg, a place closely blocked up by the enemy. Here he drove from an advantageous post four regiments of Saxon cuirassiers, having killed or taken prisoners 400 men; after which he soon forced them to

88 The Saxons a general engagement. The numbers were very unequal, entirely de- Bannier's army amounting to 9000 horse and 7000 foot, feated by and the Saxons to 15,000 horse and 13 battalions of foot. Bannier. The battle began with great fury; the right wing of the Swedes was almost oppressed by numbers before the left could come to their assistance. They were ten times driven back, and as often returned to the charge. At last they made such a desperate effort, that the enemy were entirely broken and defeated. Five thousand were killed on the spot, 3000 wounded, and as many taken prisoners, together with 150 colours and standards, and several pieces of cannon.

Thus ended the campaign of 1636, in a manner highly honourable to the Swedes. Some fruitless negotiations were set on foot during the winter; but these coming to nothing, Bannier quitted his winter-quarters very early in the season; and falling upon eight regiments of Saxons cantoned at Eulenburg, pursued them to Torgau, where he obliged them to surrender at discretion. Another party of Saxons was defeated in the neighbourhood of Leipzig; after which he proposed investing that city. But in this project he was disappointed by the Imperialists penetrating into Thuringia. He then called in all his detachments, with a view to prevent them from crossing a river named *Sala*; but in this also he was disappointed. However, he had the good fortune to defeat 2000 Imperialists near Pegau, and to destroy several detachments that attempted to obstruct his march. Yet, notwithstanding all these successes, Bannier found his situation every day more straitened, from the continual increase of the enemy's forces; which obliged him at last to retreat into Pomerania, out of which he soon drove count Gallas.

90 The affairs of the Swedes were now once more reduced to the brink of ruin, through the unguarded conduct of general Wrangel, who had also an army in Pomerania. After Bannier had driven count Gallas out of the province as above mentioned, Wrangel, imagining himself perfectly secure, cantoned his troops, and extended his quarters, the better to accommodate his army. But Gallas, being informed of this proceeding, suddenly returned, ravaged all Upper Pomerania, and reduced the towns of Usedom, Dornmin, and Wollin; after which, leaving garrisons in the fortresses, he returned to his winter-quarters in Saxony.

91 This unfortunate campaign counterbalanced all the advantages of the former. Wrangel was so struck with the suddenness of the blow, that he could take no measures for opposition. Some of the Swedish allies again fell off, and took up arms against them. In 1638, the Swedish affairs again began to revive in this quarter, through the excellent conduct of Bannier, who defeated count Gallas with the loss of 3000 men killed and taken prisoners. Pursuing his good fortune, he so harassed the count, that he obliged him in great haste to repass the Elbe, and take shelter in the hereditary dominions of Austria. Great as Bannier's exploits had been, however, they were eclipsed by those of duke Bernard. That general had so increased his army in the Protestant cantons of Switzerland, and in Franche Comte, that he found himself in a condition to act without the assistance of the French, who indeed were but treacherous allies. Advancing to the Rhine, he seized on Seckingen and Laffuburg, and laid siege to Rheinfeld. The Imperialists, in conjunction with the troops of Bavaria, advanced to the relief of the place. An engagement ensued, in which

the victory was disputed: the enemy threw succours into the city, and the duke withdrew his army. Within a month he gave them battle a second time; and so completely defeated them, that only one Imperial officer above the rank of a captain escaped being killed or taken prisoner. He then renewed the siege of Rheinfeld; which he reduced, as well as several other important places. Advancing to Brisac, he blocked it up with a design of forcing the garrison to surrender by famine. General Gotz, with 12,000 men, attempted to throw in 1000 waggons of provisions; but he was defeated, with the loss of all his men except 2500. Duke Charles of Lorraine, with 4000 men, joined the remains of Gotz's army, in order to relieve the town; but being surprised by Bernard, his whole army was cut in pieces. A third attempt was made by Gotz, but it proved as unsuccessful as the former; and the place being reduced to great straits, was obliged to capitulate.

In January 1639, the two victorious generals Bernard and Bannier prepared to attack the enemy on their own ground. Bannier made an irruption into the territories of Anhalt and Halberstadt. Leaving his infantry behind, he pushed on with his cavalry, and surprised Salis, grand-master of the Imperial artillery. After a bloody conflict, the Swedes gained a complete victory, seven regiments of the enemy being cut in pieces. Next entering Saxony, he defeated four regiments of the enemy, obliging a much larger body to take shelter under the cannon of Dresden. Hearing that the Saxons were encamped near Chemnitz, where they waited to be joined by the Imperialists, he resolved to attack them before this junction could be effected. The same good fortune still attended his arms, and the Saxons were almost all killed or taken. Bannier next entering into Bohemia, laid the country under contribution; after which, returning cross the Elbe, he fell on general Hofskirk, who was encamped near Brandeiz with 10 regiments of horse and several battalions of foot. Him he defeated with the loss of 2000 men. The remains of the Imperial forces were pursued to the walls of Prague, and the generals Hofskirk and Montecuculi were taken prisoners. Yet, notwithstanding these constant successes, the enemies of Bannier multiplied daily. He had expected an insurrection in his favour in Silesia or Bohemia; but no such event took place. The Protestant princes, overawed by the enemy, did not send him the necessary assistance. Undismayed, however, by difficulties or danger, Bannier performed wonders. He defeated a body of Imperialists at Glatz; three times he drove the Saxons from their camp at Firn; and yet was forced to evacuate the place, because he could not spare a garrison. His army being destitute of the means of recruiting, was considerably diminished in number; yet with it he reduced a number of towns, and obtained a variety of other important advantages, when on a sudden all his hopes were blasted by the death of the duke of Saxe-Weymar; poisoned, as was supposed, by the French, who were desirous of getting the town of Brisac into their hands, from which the duke prevented them.

94 The difficulties to which Bannier was now reduced proved extreme. The French monarch took upon him to dis- pose of the army and conquests of Bernard as he thought of the proper. Brisac, and other places of importance, he kept to himself; after getting possession of which, the French endeavoured, as much as possible, to ruin the army. In the mean time, the Imperial army under Piccolomini, in the Netherlands, was prodigiously augmented; and the archduke Leopold-William, in quality of generalissimo, was assembling his whole strength to crush the Swedes at once. Bannier, however, did not despair. George duke of Lunenburg having conceived some disgust at the emperor, Bannier hoped

Sweden.

94 Bannier de-
feats the
enemy in
several en-
gagements.

95 Death of
the duke
of Saxe-
Weymar.

96 Treachery
of the
French.

Sweden. to gain him over: he therefore approached nearer to his country; by which also he drew towards the armies of Weymar and Hesse. In his way he cut in pieces a body of 3000 Croats. General Konigsmark routed the Imperialists at Gera; a second time at Scholen; and a third time entirely defeated them near Leipzig. Bannier was very pressing on the allies to join him; and at last, in 1640, he was joined by the Weymar army under the dukes of Longueville and Gubrien, a body of Russians led by general Melander, and the troops of Lunenburg commanded by general Klitzing. The army now amounted to 22 battalions of infantry and 22,000 horse; so that they were much more than a match for their enemies, had they been under the sole direction of Bannier. But unanimity was wanting; every one would be supreme in the command; and Bannier, the best general of them all, had the least influence. Instead of those masterly and decisive strokes by which the Swedes had hitherto distinguished themselves, the armies continued looking at one another, each suffering the rigours of famine. At last Bannier, resolving to expose his troops no longer, set out for Thuringia, through Franconia, to seize an advantageous post on the Maine; but as he advanced to the Sala, he found the Imperialists entrenched on the other side. Finding it impossible to force a passage, he took the road through Hesse, where his troops suffered greatly by famine. Here he proposed to fight the enemy; but the Landgrave and duke of Lunenburg refused their consent. Upon this he threatened to leave them to the mercy of the confederates, and thus obliged them to be somewhat more pliant. None of those brilliant successes, however, now attended the operations of the Protestant allies: the campaigns of 1640 and 1641 were spent in useless marches and countermarches; serving only to bring the army into the greatest dangers, from which they were as constantly relieved by the active and intrepid Bannier. At last this brave general, worn out with perpetual fatigues, died of a fever in the year 1641, leaving the Swedish army in a worse situation than ever.

97
Imperialists defeated by Konigsmark.

98
Death of Bannier.

99
A Swedish detachment cut in pieces.

100
The Imperialists defeated.

101
General Torsten takes the command of the Swedish army.

The Imperialists were too well acquainted with the abilities of Bannier, not to take advantage of the opportunity offered by his death. A Swedish detachment was cut in pieces at Quidlenberg. The Swedish army, accustomed only to be obedient to Bannier, became mutinous, and Piccolomini resolved to fall upon them with his whole force. But the four generals, Wrangel, Konigsmark, Wittemberg, and Pful, having convinced the soldiers of the necessity of defending themselves, made such excellent dispositions, that the Imperialists durst not attack them. Piccolomini then detached part of his army to attack the Hessians in their quarters; but Wrangel and Konigsmark threw themselves in their way, and defeated them with the loss of 2000 men. This victory, however, did not retrieve the Swedish affairs. Dissensions and mutiny began again to take place in the army to such a degree as threatened its dissolution. In 1642 general Torsten was sent from Sweden, with a large sum of money and a strong reinforcement, to take upon him the supreme command. This general was inferior in abilities to none of his predecessors, and designed without loss of time to come to an engagement; but the Weymar army separating from him, put an end to that design, and obliged him to remain for a considerable time inactive. He was also confined to his chamber for some time by a dangerous gout; and thus a report of his death being spread, the Imperialists were encouraged to begin a long march through roads scarce passable, in hopes of surprising the Swedish army without a general. Torsten having intelligence of this, seized an advantageous post, which could not be forced; and thus obliged the enemy to retreat, after having

suffered as much by their fatiguing march as if they had fought a bloody battle. Then joining general Stalhanch, who had been driven by the Imperialists out of Silesia, he reduced the town of Great Glogau, with a number of other important places; after which he laid siege to Schweidnitz. The duke of Saxe-Lawenburgh, at the head of all his cavalry, endeavoured to throw in succours; but was defeated with the loss of 3000 men. He himself was taken prisoner, and died of chagrin a few days after. In consequence of this defeat Schweidnitz surrendered at discretion; and Torsten having sent a detachment to invest the city of Neisse, proceeded with the rest to drive the enemy entirely out of Silesia. This he effectually performed; obliging them to retire over barren mountains, almost famished for want of provisions, and harassed by his light troops; so that this lately formidable army was almost entirely ruined. With his victorious troops the Swedish general then poured into Moravia; where, in five days, he reduced the strong town of Olmutz (which not long ago sustained a siege of as many weeks by the late king of Prussia). Litta and Newstadt shared the same fate; after which, the Swedes, returning suddenly to Silesia, made themselves masters of Opplein and Brieg, and laid siege to Breslau. Here the garrison made such an obstinate defence, that the Imperialists had time to assemble under the conduct of the archduke Leopold, and come to their relief. As Torsten was greatly inferior in number, he raised the siege; but appeared so formidable in his retreat, that the enemy durst neither attack him, nor attempt to prevent his encamping in a very advantageous situation. The Imperialists took this opportunity of laying siege to Glogau; but after having lost a great number of men, they were forced to abandon the enterprise on the junction of Wrangel with Torsten; by which means the Swedes were once more in a condition to face their enemies in the field.

Torsten now projected an irruption into Bohemia, and putting his army into winter-quarters in that country; but in this he was prevented by the vigilance of the enemy: however, he reduced the city of Zittau, where, for the first time, a cartel for prisoners was established; by which means the Swedish army was considerably augmented. Thus disappointed in his designs on Bohemia, Torsten directed his course to Leipzig, which he intended to invest. The Imperial generals assembled their whole force, and set out to relieve that important place. The two armies soon came in sight of each other; and a furious cannonading was the prelude to a general engagement. A single bullet had almost proved fatal to the Swedish cause. It carried away the furniture of Torsten's horse, killed the count Palatine's horse, pierced general Rabenau through the body, took off the head of a celebrated counsellor named Crabbe, and carried away the leg of a private soldier. The Swedes, as soon as the armies came up, behaved with their wonted resolution, and after an obstinate conflict obtained a complete victory; 5000 of the enemy being killed on the spot, 3000 wounded, and as many taken prisoners. This victory was followed by the immediate surrender of Leipzig; and in all probability the Swedes would have finally triumphed over all their enemies, had not a rupture with Denmark ensued. Torsten and Horn behaved with their usual valour in Holstein and Schonen, while general Konigsmark distinguished himself in Germany; but the ruin of the Weymar army, which was totally defeated with the loss of one half its number at Dettingen by the Bavarians, proved a dreadful blow, from which the Swedes could scarce recover themselves. Indeed, notwithstanding the valour and success of the Swedes, their affairs in Germany must have gone to wreck in the campaigns of 1643 and 1644, had not the French

Sweden.
102
Reduced several towns.

103
Drives the Imperialists out of Silesia, and takes Olmutz, &c.

104
Entirely defeats them at Leipzig.

105
War with Denmark.

106
The Swedes defeated at Dettingen.

Sweden. French under Condé and Turenne made a most powerful diversion, and performed such exploits as immortalized the names of these two generals.

107 An advantageous peace with Denmark.
In 1645, the war against Denmark was pushed with such vigour, that a peace, very honourable and advantageous for Sweden, was concluded; and thus Torstenson was again at liberty to act against the Imperialists. He now took measures for carrying the war into the heart of the Austrian dominions. Hatfield assembled a considerable army to oppose the Swedes; and the emperor came in person to Prague to animate his troops. The two armies came in fight at Jancowitz, and both prepared for an engagement. The valour of the Swedes once more prevailed; and they totally defeated their enemies. Four thousand of the Imperialists were killed on the spot, among whom were general Hatfield and a great number of officers; and near 5000 were taken prisoners. No great advantages, however, were derived from this victory. Some towns indeed were reduced; but at last Torstenson was obliged to retire into Moravia, where he put his army into winter-quarters; and in the beginning of the year 1646 resigned the command to Wrangel.

108 The Imperialists entirely defeated at Jancowitz.
The new general conducted the Swedish affairs with great ability and success; till at last the Imperialists, finding themselves finally unable to drive the Swedes out of Germany, concluded a peace with them in 1648. This was the memorable treaty of Westphalia, by which the Germanic constitution was settled upon its ancient principles, and those implacable disputes which had so long torn the empire were ended; the duchies of Bremen and Verden, all the Upper and part of Lower Pomerania, the city of Wismar and the isle of Rugen, were assigned to Sweden, and a gratification of five millions of crowns was given to the army.

110 Treaty of Westphalia.
Sweden now enjoyed some years of repose. Charles Gustavus, count Palatine, having gained the favour of Christina, was appointed generalissimo of the forces, and heir-apparent to the crown. A marriage was proposed between them; but the queen would never listen to this or any other proposal of the kind. In 1650, the ceremony of the queen's coronation was performed; but in four years thereafter, she resigned the crown in favour of Gustavus. (See the article CHRISTINA).

111 Charles Gustavus appointed heir to the crown of Sweden.
The new king found himself involved in considerable difficulties on his accession to the throne. The treasury was quite exhausted; great part of the revenue was appointed for the support of Christina's household; the people were oppressed with taxes; and the nation having been disarmed for several years, began to lose its reputation among foreigners. To remedy these evils, Charles proposed to resume all the crown-lands which had been alienated by grants to favourites during the late reign; to repeal a duty which had been laid upon salt; to put the kingdom in a posture of defence; and to enter upon a war with some neighbouring state. Under a pretence, therefore, that Casimir king of Poland had questioned his title to the throne, he began to make preparations for invading that kingdom. Several embassies were sent from Poland to Stockholm; but some point of ceremony always disappointed them of an audience of the king; so that they were obliged to return without their errand. As soon as matters were in readiness, General Wittenberg made an irruption into Poland from the side of Pomerania. The Poles opposed him with an army of 15,000 men; but instead of fighting, they began to negotiate, and in a short time entirely dispersed themselves. Charles himself soon followed with a powerful army, and pursued his march without obstruction, all the cities throwing open their gates to him as he approached, and offering to supply him

112 State of Sweden on the accession of Charles.
with necessaries. As he advanced to Cracow, Casimir resolved to make one effort to save his capital. His army amounted only to 10,000 men; and these were unfortunately such as had never stood fire. After a feeble resistance, they fled with precipitation, having lost 1000 men killed and taken prisoners. A few days after this Charles defeated the Poles a second time, about eight leagues from Cracow; upon which Casimir fled with his family to Oppelen in Silesia. The capital was then invested; and though defended with the utmost valour by Stephen Czarneski, was in a short time obliged to capitulate. Thus in less than three months Charles apparently became master of Poland; but it soon became evident that the Poles had no intention of abandoning their former sovereign.

113 War with Poland resolved on.
In 1656 a war took place with the elector of Brandenburg. While Charles was employed in the conquest of Poland, that prince had invaded the Royal and Ducal Prussia, and reduced the most considerable towns with little opposition. The king of Sweden took umbrage at his progress; and having marched against him, defeated his forces in several slight encounters, and obliged him to own that he was a vassal of Sweden. These rapid conquests alarmed all Europe; and the different powers sought for means of driving the Swedes out of Poland, which they had so unexpectedly and unjustly seized. The Poles were no sooner assured that they should be assisted, than they everywhere revolted and massacred the Swedes. Casimir returned from Silesia; and those very troops and generals who had before submitted to Charles without opposition, now ranged themselves under the banners of his antagonist. Charles immediately marched from Prussia to chastise the insolence of the Poles, and totally defeated a body of 12,000 men under the command of Czarneski. This did not hinder all the Poles incorporated with his troops to desert; which considerably reduced his army; and the campaign being performed in the depth of winter, he was at last obliged to retreat to Prussia. In his march he was harassed by the Poles; and a body of 4000 Swedes was surprised and defeated by them at Warka. This loss, however, was soon after recompensed by a complete victory gained by Adolphus the king's brother and General Wrangel over Czarneski. In the meantime the king was taking measures for laying siege to Dantzic; but was prevented by the Dutch, who threatened to oppose him, unless a proper regard was paid to their interest. Charles accordingly granted them advantageous terms; and afterwards gained over the elector of Brandenburg, by ceding to him the sovereignty of Prussia, that he might be at liberty to turn his whole strength against Poland.

Sweden.
114 The Poles defeated, and the kingdom reduced.
By the treaty just concluded with the elector, the latter was to assist Charles in his war with Poland; but the elector had so procrastinated matters, that the Poles, having obtained assistance from the Tartars, had reduced the city of Warsaw. The two princes, however, now marched in concert against their enemies, who were encamped in a strong situation in the neighbourhood of the city above-mentioned, their camp being fronted by the Vistula. The Poles were driven from their entrenchments with prodigious slaughter, and a vast number taken prisoners. The Poles and Tartars then laboured to break the alliance; with which view they entered Ducal Prussia, and defeated the electoral army, taking prince Radzivil and other persons of distinction prisoners. The Swedes soon had their revenge. General Steinbock attacked the same Polish army at Philippowa, and overthrew it with such slaughter as obliged the Poles for that season to quit the field. A more formidable enemy than the Poles now began to make their appearance. The Russians invaded the provinces of Carelia, Ingermania, and Livonia;

115 War with the elector of Brandenburg.
The king of Sweden took umbrage at his progress; and having marched against him, defeated his forces in several slight encounters, and obliged him to own that he was a vassal of Sweden. These rapid conquests alarmed all Europe; and the different powers sought for means of driving the Swedes out of Poland, which they had so unexpectedly and unjustly seized. The Poles were no sooner assured that they should be assisted, than they everywhere revolted and massacred the Swedes. Casimir returned from Silesia; and those very troops and generals who had before submitted to Charles without opposition, now ranged themselves under the banners of his antagonist. Charles immediately marched from Prussia to chastise the insolence of the Poles, and totally defeated a body of 12,000 men under the command of Czarneski. This did not hinder all the Poles incorporated with his troops to desert; which considerably reduced his army; and the campaign being performed in the depth of winter, he was at last obliged to retreat to Prussia. In his march he was harassed by the Poles; and a body of 4000 Swedes was surprised and defeated by them at Warka. This loss, however, was soon after recompensed by a complete victory gained by Adolphus the king's brother and General Wrangel over Czarneski. In the meantime the king was taking measures for laying siege to Dantzic; but was prevented by the Dutch, who threatened to oppose him, unless a proper regard was paid to their interest. Charles accordingly granted them advantageous terms; and afterwards gained over the elector of Brandenburg, by ceding to him the sovereignty of Prussia, that he might be at liberty to turn his whole strength against Poland.

116 The Poles revolted.
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117 Charles gains a victory, but is obliged to retire.
The king of Sweden took umbrage at his progress; and having marched against him, defeated his forces in several slight encounters, and obliged him to own that he was a vassal of Sweden. These rapid conquests alarmed all Europe; and the different powers sought for means of driving the Swedes out of Poland, which they had so unexpectedly and unjustly seized. The Poles were no sooner assured that they should be assisted, than they everywhere revolted and massacred the Swedes. Casimir returned from Silesia; and those very troops and generals who had before submitted to Charles without opposition, now ranged themselves under the banners of his antagonist. Charles immediately marched from Prussia to chastise the insolence of the Poles, and totally defeated a body of 12,000 men under the command of Czarneski. This did not hinder all the Poles incorporated with his troops to desert; which considerably reduced his army; and the campaign being performed in the depth of winter, he was at last obliged to retreat to Prussia. In his march he was harassed by the Poles; and a body of 4000 Swedes was surprised and defeated by them at Warka. This loss, however, was soon after recompensed by a complete victory gained by Adolphus the king's brother and General Wrangel over Czarneski. In the meantime the king was taking measures for laying siege to Dantzic; but was prevented by the Dutch, who threatened to oppose him, unless a proper regard was paid to their interest. Charles accordingly granted them advantageous terms; and afterwards gained over the elector of Brandenburg, by ceding to him the sovereignty of Prussia, that he might be at liberty to turn his whole strength against Poland.

Sweden. Livonia; while the elector of Brandenburg began to waver in his fidelity. To preserve this only ally at such a critical juncture, Charles was obliged to give him more advantageous terms than those already mentioned; while the Russians were repulsed in the provinces of Carelia and Ingermania. But in Livonia they had better success, two important fortresses falling into their hands; after which they laid siege to Riga. For seven months they battered the walls of this city, without once venturing to pass the ditch or storm the practicable breaches. The besieged, under the command of Magnus de la Gardie and Simon Helmfield, defended themselves with the greatest intrepidity; cutting off many thousands of the enemy in the sallies they made. At last they attacked the Russian camp, drove them out of it with great slaughter, and obliged them to raise the siege with precipitation.

120
The Rus-
sians invade
the Swedish
dominions.

121
Are defeated
before
Riga.

Charles, notwithstanding the number of his enemies, was now become so formidable by the valour and discipline of his troops, that whole armies often fled on the very news of his approach. At last, in 1657, the Poles, finding they could not resist him in the field, contented themselves with harassing the Swedes on their march, and cutting off the foragers and convoys. This proved much more destructive to the Swedes than their former method; so that Charles was obliged to enter into an alliance with Ragotski prince of Transylvania, by assigning him certain provinces in his neighbourhood, in order to furnish himself with irregular troops, who might fight the Poles in their own way. This, however, proved of no real advantage; for the confederates, after spending a whole campaign in Lithuania, were obliged to return without accomplishing more than the reduction of a single fortress; upon which Charles returned with the Swedish army to Prussia.

122
Charles enters
into an
alliance
with Ra-
gotski
prince of
Transylva-
nia.

123
Leopold
king of
Hungary
declares
against
Sweden.

124
Ragotski's
army de-
stroyed by
the Poles
and Tar-
tars.

125
He is de-
feated and
killed by
the Turks.

126
Bravery
and success
of general
Wrangel.

Leopold, the young king of Hungary, having beheld for a long time the Swedes with a jealous eye, now resolved to declare for Poland. The more effectually to curb the ambition of the Swedish monarch, he solicited the king of Denmark to come to a rupture with him. This was instantly complied with, and the Danes invaded Bremen. Charles hastened to oppose this new enemy; which gave such offence to Ragotski, that he neglected to take the proper measures for his own defence in the absence of the Swedes, and suffered his army to be destroyed by the Poles and Tartars. At the same time the Turks invaded Transylvania, under pretence that Ragotski, being a vassal of the Grand Signior, had no right to invade Poland without his leave. Ragotski opposed them in the field; where he was defeated and killed, leaving Charles destitute of the only ally on whom he could have depended.

The king, however, not dismayed by this misfortune, traversed Pomerania and the duchy of Mecklenburg; after which he fell upon Holstein, while general Wrangel with another corps entered the duchy of Bremen. The latter executed his measures with the utmost vigour and intrepidity. In 15 days he retook all the towns which the enemy had reduced; defeated and drove the Danish army out of the country, killing 3000 of their best soldiers. In Holstein the king reduced several fortresses, laid Itzehoe in ashes, defeated a body of Danes, and laid siege to Frederic-Udda, into which the Danes had thrown a strong garrison. The conduct of this siege he left to Wrangel, he himself retiring to Wismar in order to observe the situation of affairs in Poland; but no sooner was he gone than Wrangel attacked the place with such fury, that he became master of it in two hours. In the province of Halland the Swedes were defeated; but the enemy derived no advantage from their victory: at sea the fleets met, and maintained a hot engagement for two days, without any considerable advantage on

either side. In Poland matters went on much worse. The house of Austria had now declared for Casimir; a German army entered Poland; and reduced Cracow, though not without great loss to themselves. Czarneski entered Pomerania, where he butchered the unhappy peasants without mercy; but on the approach of Charles he fled as usual, having gained nothing by his expedition but the character of a cruel barbarian.

The king of Sweden was now surrounded by enemies. The elector of Brandenburg had declared against him; and he had besides to engage the armies of Austria, Poland, Russia, and Denmark, in the field. In this dangerous situation he resolved to attack Denmark, in such a manner as should oblige that power to come to a speedy accommodation. His designs were forwarded by a very early frost, which enabled him to transport his troops without the expence and trouble of shipping. Having passed over on the ice to the island of Funen, he cut in pieces a body of 4000 Danish soldiers and 500 peasants. The whole island was reduced in a few days; after which he passed to Langland, then to Laaland, after that to Falstred, and lastly to Zealand. The Danes were terrified at this unexpected invasion, and were giving themselves up to despair, when Charles offered to conclude a peace upon equitable terms. The king of Denmark very gladly consented; but with a design to renew the war as soon as he thought it could be done with safety. By this treaty, called the *treaty of Roschild*, concluded on the 12th of March 1658, the provinces of Schonen, Halland, and Bleking, Lyfter, and Huwen, the isle of Borkholm, the baillies of Bahus and Drontheim in Norway, were yielded to Sweden, and a free passage through the Sound was granted to the Swedish ships.

No sooner was Charles retired, than the king of Denmark began to act against him in an underhand manner; on which, resolving to anticipate him in his designs, he appeared unexpectedly with a fleet before Copenhagen. Had he given the assault immediately, before the inhabitants had time to recover from their surprise, it would probably have surrendered at once; but, by landing at the distance of 17 miles, he gave them time to prepare for their defence: the siege proved extremely tedious, and at last the place was relieved by a Dutch fleet. On this Charles converted the siege into a blockade, which continued till the end of the war. Wrangel reduced the strong fortresses of Cronenburg; and the Swedish forces were so judiciously posted, that all Denmark was in a manner blocked up; when, in 1660, king Charles died of an epidemical fever: and thus an end was put, for that time, to all the ambitious designs of Sweden.

The new king Charles XI. was a minor at the time of his father's death; and as the kingdom was involved in a dangerous war with so many enemies, the regency determined to conclude a peace, if it could be obtained on reasonable terms. A treaty was accordingly concluded at Oliva; by which Casimir renounced his pretensions to the crown of Poland, and that republic gave up all pretensions to Livonia. Bornholm and Drontheim were ceded to Denmark; and an equivalent in Schonen remained with Sweden. During the minority of the king, nothing remarkable occurs in the history of Sweden. In 1672 he entered into alliance with Louis XIV. which two years after involved him in a war with the elector of Brandenburg. At first the Swedes carried all before them; and general Wrangel having fallen sick, they continued their conquests under another named *Mardenfeldt*. Almost all the towns in Brandenburg were reduced, when the elector arrived with an army to the relief of his distressed subjects. He retook several towns, defeated Mardenfeldt in a general engagement, and soon after forced them to abandon all their conquests. In conjunction

Sweden.
127
The house
of Austria
declares
against
Sweden.

128
Charles in-
vades Den-
mark with
great suc-
cess.

129
Peace con-
cluded.

130
The war
renewed,
and Copen-
hagen be-
sieged.

131
Death of
Charles
Gustavus.

133
Treaty of
Oliva.

134
War with
Branden-
burg.

135
The Swedes
defeated by
land and
sea.

Sweden. with the Danes, he then invaded the Swedish dominions; many places of importance were reduced; and, in 1676, Sweden received a most destructive blow by the defeat of her fleet in an engagement with the combined fleets of Denmark and Holland. Soon after this the king took the government into his own hands, and in some degree restored the fortune of Sweden; but though matters went on in a more prosperous way where the king commanded in person, the same losses and disgrace attended the Swedish arms in every other quarter. In Pomerania, count Königsmark lost every place of importance excepting Stralsund, Stetin, and Gripswald. In 1678, the Swedish fleet was defeated in two engagements. At Landskroon a most obstinate battle was fought from ten in the morning till six at night; when both parties were obliged, by their fatigue, to retire to their respective camps. At Oldeval in Norway, the Swedes were defeated; and the Danes laid desolate the islands of Oeland, Smaalund, Unno, and Kuno; while the electoral troops and Imperialists reduced count Königsmark to the utmost distress in the neighbourhood of Stralsund.

136
Their affairs every-where go to wreck.

In this deplorable situation of affairs count Königsmark found an opportunity of attacking his enemies to such advantage, that he obtained a complete victory; after which he ravaged the duchy of Mecklenburg. Yet notwithstanding this success, he could not prevent the elector from reducing Stralsund; after which he was obliged to evacuate Pomerania; and, to complete his distress, the fleet which transported the Swedish army from Pomerania was wrecked on the coast of Bornholm; by which accident 2000 persons were drowned, and the remainder plundered and taken prisoners by the Danes, though they had been furnished with passports from king Frederic.

137
Peace concluded.

In this unprosperous situation of affairs a peace was concluded at St Germain's between France and her enemies, by which the Swedes and Danes were left to decide their quarrel by themselves. Denmark was by no means a match for Sweden, even in the distressed situation to which she was reduced: for which reason a treaty was instantly concluded, on terms much more favourable to Sweden than could have been expected; and the peace was confirmed by a marriage between Charles and Ulrica Eleonora, daughter to the king of Denmark. From this time the Swedish monarch applied himself to the reformation of the state; and by artfully managing the disputes between the nobility and peasants, he obtained a decree of the states empowering him to alter the constitution as he pleased. Being thus invested with absolute power, he proceeded to take some very extraordinary measures. In 1685 it was projected to liquidate the public debts by raising the nominal value of money, without adding any thing to its intrinsic value. This was put in execution the following year, by which the creditors of the government lost upwards of nine millions of crowns. This, with some other arbitrary steps taken about the same time, disgusted all the nobility, merchants, and crown-creditors. In Livonia they were highly resented; and remonstrances were repeatedly sent by the hands of deputies, who had orders to insist upon their privileges confirmed by many acts of the king's predecessors. The deputies could obtain nothing, so that the diet was assembled. On their report the body of nobility resolved to draw up a stronger remonstrance than any of the former, to be presented to the king by captain Patkul one of the deputies, who had already distinguished himself by his boldness and attachment to liberty. His public spirit, however, produced no other effect than to procure his own destruction. An accusation was drawn up against all the remonstrants, but especially Patkul. He was sentenced to lose his right hand, then to be deprived of his life, honours, and estates; to have the latter confiscated to

138
Charles becomes absolute.

139
Disgusts many of his subjects.

140
Boldness and misfortune of Captain Patkul.

the crown, and his papers burnt by the hands of the common executioner. The accusation was declared unjust by the university at Leipzig: but notwithstanding this, Patkul was obliged to fly his country, to avoid the execution of his rigorous sentence; which, however, fell upon him with redoubled fury in the subsequent reign, of which an account is given under the article PATKUL.

On the 15th of April 1697, died Charles XI. leaving his crown to his son, the celebrated Charles XII. at that time a minor. On his accession he found himself under the tuition of his grandmother Eleonora, who had governed the kingdom during the minority of the late king. Though Charles was at that time only 15 years of age, he instantly showed a desire of taking the government into his own hands. His counsellors, count Piper and Axel Sparre, signified his desire to the queen-regent. They were by her referred to the states; and there all were unanimous: so that the queen, finding that opposition would be vain, resigned her power with a good grace; and Charles was invested with absolute authority in three days after he had expressed his desire of reigning alone. He was scarce seated on the throne when a powerful combination was formed against him. King Augustus of Poland formed designs on Livonia; the king of Denmark revived the disputes he had with the duke of Holstein, as a prelude to a war with Sweden; and Peter the Great of Muscovy began to form designs upon Ingria, formerly a province of Russia. In 1699 the king of Denmark marched an army into Holstein. Charles sent a considerable body of troops to the duke's assistance; but before their arrival the Danes had ravaged the country, taken the castle of Gottorp, and laid close siege to Tonningen. Here the king of Denmark commanded in person; and was assisted by the troops of Saxony, Brandenburg, Wolfenbuttle, and Hesse-Cassel. England and Holland, as guarantees of the last treaty with Denmark, in concert with Sweden, joined Charles against this confederacy, and sent fleets to the Baltic. They proposed a termination of the war upon equitable terms; but these were haughtily refused by the Danish monarch, who despised the youth and inexperience of Charles, and relied too much upon the alliance he had formed with Saxony, Brandenburg, Poland, and Russia. The town of Tonningen, however, resisted all his efforts; and when he ordered the place to be stormed, he had the mortification to see his troops driven headlong from the walls by a handful of Swedes under general Bannier.

Sweden.

141
Charles XI. dies, and is succeeded by his son Charles XII.

142
He takes the government into his own hands at the age of 15.

143
A powerful combination formed against him.

144
Holstein ravaged by the Danes.

145
They are repulsed at Tonningen.

146
Charles sets out from Stockholm, and defeats the fleet of the allies.

147
Obliges the Danes to make peace.

148
Marches against the Russians.

In the year 1700, Charles, having entrusted the affairs of the nation with a council chosen out of the senate, set out on the 8th May from his capital, to which he never afterwards returned. He embarked at Carlscroon, and defeated the fleet of the allies. Having made a descent on the island of Zealand, he defeated a body of cavalry that opposed his march, and then proceeded to invest Copenhagen by sea and land. The king of Denmark then saw the necessity there was either of having his capital destroyed, or of doing justice to the duke of Holstein. He chose the latter; and a treaty was concluded in eleven days, upon much the same terms as formerly. Charles, being thus at liberty to turn his arms against the other princes who had conspired his destruction, resolved to lead his army against Augustus king of Poland; but on his way he received intelligence that the czar of Muscovy had laid siege to Narva with 100,000 men. On this he immediately embarked at Carlscroon, though it was then the depth of winter, and the Baltic scarce navigable; and soon landed at Pernaw in Livonia with part of his forces, the rest being ordered to Reval. His army did not exceed 20,000 men; but they were the best soldiers in Europe, while the Russians were only an undisciplined multitude.

Sweden. multitude. The czar, however, had thrown every possible obstruction in the way of his antagonist. Thirty thousand men were posted in a defile on the road, to oppose his passage; and this corps was sustained by a body of 20,000 others, posted some leagues nearer Narva. The czar himself had set out to hasten the march of a reinforcement of 40,000 men, with whom he intended to attack the Swedes in flank and rear. But the celerity and valour of the

149
Defeats two
Russian ar-
mies, and
attacks the
Czar's
camp.

Swedes baffled every endeavour. With 4000 foot and an equal number of horse the king set out, leaving the rest of the army to follow him at their leisure. With these he attacked and defeated the Russian armies one after another, pushing his way to the czar's camp, which he gave immediate orders for attacking. This camp was fortified by lines of circumvallation and contravallation, by redoubts, by 150 pieces of brass cannon placed in front; and was defended by an army of 80,000 men: yet so violent was the attack of the Swedes, that in three hours the entrenchments were carried; the king with 4000 men that composed the wing he commanded in person, pursued a flying army of of 50,000 to the river Narva. The bridge broke down by the weight of the fugitives, and the river was instantly covered with their bodies. Great numbers returned in despair to their camp, where they defended themselves for a while; but at last the generals Gallowin and Frederowitz, who commanded them, surrendered. Thirty thousand were killed in the intrenchments and in the pursuit, or drowned in the river; 20,000 surrendered at discretion, and were dismissed unarmed; while the rest were totally dispersed. An hundred and fifty pieces of fine cannon, 28 mortars, 151 pair of colours, 20 standards, and all the baggage of the enemy, were taken. Among the prisoners were the duke de Croy, the prince of Georgia, and seven other generals. Charles behaved with the greatest generosity to the conquered. Being informed that the tradesmen of Narva had refused credit to the officers whom he detained prisoners, he sent 1000 ducats to the duke of Croy, and to every other officer a proportionable sum.

150
The camp
forced, and
the Russians
defeated
with great
slaughter.

151
Generosity
of Charles.

Peter was advancing, with 40,000 men to surround the Swedes, when he received intelligence of the dreadful defeat at Narva. He was greatly chagrined; but, comforting himself with the hopes that the Swedes would in time teach the Russians to beat them, he returned to his own dominions, where he applied himself with the utmost diligence to the raising of another army. He evacuated all the provinces which he had invaded, and for a time abandoned all his great projects, thus leaving Charles at liberty to prosecute the war against Poland.

152
Treaty be-
tween the
Czar and
king of Po-
land.

As Augustus had expected an attack, he endeavoured to draw the czar into a closer alliance with him. The two monarchs had an interview at Birsen, where it was agreed that Augustus should lend the czar 50,000 German soldiers, to be paid by Muscovy; that the czar should send an equal number of his troops to be trained up to the art of war in Poland; and that he should pay the king three millions of rix-dollars in the space of two years. Of this treaty Charles had notice, and by means of his minister count Piper entirely frustrated the scheme.

153
Charles
marches a-
gainst the
Saxons

In 1701, as early as the season permitted, Charles, having received a reinforcement from Sweden, took the field, and appeared suddenly on the banks of the Duna, along which the Saxon army was posted to receive him. The king of Poland at that time being sick, the army was commanded by Ferdinand duke of Courland, marischal Stenau, and general Paykel, all officers of valour and experience. They had fortified certain islands in the mouth of the river, and taken every other precaution against an attack; the soldiers were hardy, well-disciplined, and nearly equal to the

Swedes in number; yet Charles, having passed the river in boats with high sides, to screen the men from the fire of the enemy, attacked them with such fury, that they were entirely defeated, with the loss of 2500 killed on the spot, and 1500 taken prisoners. All the Saxon baggage, 36 pieces of cannon, five pair of colours, and six standards, fell into the hands of the Swedes.

This victory was followed by the surrender of all the towns and fortresses in the duchy of Courland. The king then passed into Lithuania, where every town opened its gates to him. At Birsen, an army of 20,000 Russians retired with the utmost precipitation on the news of his approach. Here Charles, perceiving that the kingdom of Poland was greatly disaffected to Augustus, began to project the scheme of dethroning him by means of his own subjects. This scheme he executed with more policy than he ever showed on any other occasion. The manner of putting it in execution was concerted between Radziewisch, cardinal primate of Poland, and count Piper. Intrigues and cabals were held at the house of the treacherous ecclesiastic, while he was publishing circular letters to keep the people in their duty to the king. The diet being filled with Swedish partisans, became tumultuous, and broke up in confusion. The affairs of the kingdom then fell into the hands of the senate; but here the Swedish party was as strong as in the diet. It was agreed that they should send an embassy to Charles; that the pospolite should mount, and be ready against all events; but the chief regulations respected the king's authority, which it was determined at any rate to retrench. Augustus, resolving rather to receive laws from the victorious Charles than from his own subjects, sent an embassy to him, committing the management of the whole to the counts of Konigsmark, a native of Sweden, and a lady famous for her wit and beauty. But the king refused to see her; on which she returned, chagrined and disappointed, to Warsaw. The ambassadors of the senate instantly obtained an audience; and were assured by Charles, that he took arms against the Saxons in defence of the liberties of the Poles, whom he should always regard as his best friends. Conferences were appointed to be held at Kinschin; but Charles soon after altered his mind, and told the ambassadors he would hold them at Warsaw.

Augustus, in the mean time, finding his scheme of peace frustrated, had recourse to the senate; but met with such a rough answer from them, that he determined once more to apply to Charles. To him therefore he sent his chamberlain; but a passport being forgot, the ambassador was arrested. Charles continued his march to Warsaw, which surrendered on the first summons; but the citadel held out for some days. Augustus, finding at last that no dependence was to be had on the Poles, determined to trust his fortune wholly to the Saxon army and the nobility of the palatinate of Cracow, who offered to support him to the utmost of their power. The Saxon army was now advanced to the frontiers, and Augustus immediately put himself at the head of it. Being joined by the nobility of Cracow, he found his forces to amount to 30,000 men, all brave and well-disciplined. With these he marched in quest of his enemy; who did not decline the combat, though he had with him only 12,000 men. Though the Saxons were strongly posted, having their front covered by a morass, besides being fortified with palisadoes and chevaux de frise, they were attacked with irresistible impetuosity, and entirely defeated, with the loss of 4000 killed, 2000 made prisoners, and all their baggage and cannon. This victory was followed by the loss of Cracow: after which Charles set out in pursuit of the flying army, with a design of preventing them from re-assembling; but his horse falling under him, he had the misfortune

154
Makes a se-
cond appli-
cation to no
purpose.

155
Forms a
scheme for
dethroning
Augustus.

156
Confusions
in Poland.

157
Augustus
attempts to
treat, but in
vain.

158
Makes a se-
cond appli-
cation to no
purpose.

159
Warsaw ta-
ken.

160
The Saxons
entirely de-
feated.

161
Cracow ta-
ken.

Sweden. fortune to break his thigh, by which he was confined six weeks; and thus Augustus obtained some respite. The interval he made the best use of. Having convoked a diet first at Marienburg, and then at Lublin, from them he obtained the following resolutions; that an army of 50,000 men should be raised by the republic for the service of the prince; that six weeks should be allowed the Swedes to determine whether they were for war or peace; and that the same time should be granted to the turbulent and discontented nobles of Poland to make their concessions. To counteract the effects of these resolutions, Charles assembled another diet at Warsaw; and while the two assemblies disputed concerning their rights and privileges, he recovered of his wound, received a strong reinforcement from Pomerania, and utterly defeated and dispersed the remains of the Saxon army.

162
Remains of
the Saxon
army en-
tirely de-
feated.

163
Augustus
formally
deposed,
and Stanis-
laus raised
to the
throne.

164
Warsaw re-
taken by
Augustus.

165
Excellent
conduct of
his general
Schullemb-
erg.

166
His en-
gagement
with the
Swedes.

167
His fine re-
treat.

The ill fortune of Augustus continued still to persecute him. In 1704 he was formally deposed by the diet, and the crown conferred by Charles on Stanislaus Lecinski palatine of Polesia. Augustus, however, did not yet tamely give up his kingdom. His adherents daily skirmished with the Swedes; and Augustus himself, being reinforced by 9000 Russians, retook Warsaw, and was very near surprising the new king, who lived in perfect security in the city while Charles fought in his cause. Count Horn, with 1500 Swedes, vigorously defended the citadel; but at last, finding it no longer tenable, he was obliged to surrender at discretion. The reduction of Warsaw was among the last advantages gained by Augustus in the course of this war. His troops were now composed of Saxon recruits and undisciplined Poles, who had no attachment to his person, and were ready on all occasions to forsake him. Charles and Stanislaus advanced with the victorious army; the Saxons fled before them, and the towns for several miles round sent their submissions. The Poles and Saxons were under the command of Schullemburg, a most sagacious and experienced general, who used every expedient to check the progress of the Swedes, by seizing on the advantageous posts, sacrificing small parties to the safety of the whole, and to mislead the enemy, &c. However, with all his conduct and caution, he found himself outwitted, and Charles in the neighbourhood of his camp ready to fall upon him, while he thought him at 50 leagues distance. The Swedish monarch attacked him with a superior army, but entirely composed of horse. Schullemburg had posted his men in such a manner as rendered it impossible to surround them. His first rank being armed with pikes and fuses, presented a kind of rampart of bayonets; the second line slooping over the first who kneeled, fired over their heads, while the third rank, who stood upon their feet, kept up an incessant fire, by which the Swedish horse were exceedingly galled and put in disorder. Charles lost the opportunity of cutting off the whole Saxon army, by omitting to order his men to dismount. This was almost the first time that infantry had been regularly opposed to cavalry, and the superiority of the former was evident. After the engagement had continued about three hours, the Saxons retreated in good order; which no enemy had ever done before in any engagement with Charles. The Swedes pursued their enemies towards the Oder, and forced them to retreat through thick woods, almost impervious even to infantry. The Swedish horse, however, pushed their way, and at last inclosed Schullemburg between a wood and the river, where Charles had no doubt of obliging him to surrender at discretion, or die sword-in-hand, as having neither boats nor bridges; but the genius of Schullemburg supplied every defect. In the night he ordered planks and floats of trees to be fastened together; upon which he carried over his troops, while the Swedes

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were employed in dislodging 300 men, which he had placed in a wind mill, for the purpose of defending his flank and keeping the enemy in play. Charles spoke of this retreat with admiration, and said he had been conquered by Schullemburg.

No material advantage, however, resulted from this to Augustus; who was again obliged to leave Poland, and forfeit the capital of his hereditary dominions, which he expected every moment to see invested. In the mean time, however, the Russians having recovered their spirits, fell upon the Swedes in Livonia with the utmost fury. Narva, Dorpt, and several other towns, were taken, and the inhabitants and garrisons treated with great barbarity. Soon after, an army of 100,000 Russians entered Poland. Sixty thousand Cossacks under Mazeppa entered the country at the same time, and ravaged every thing with the fury of barbarians. Schullemburg, too, perhaps more formidable than either, advanced with 14,000 Saxons and 7000 Russians, disciplined in Germany, and reputed excellent soldiers. Could numbers have determined the event of war, the Swedes must certainly have been at this time overpowered. Instead of this, however, Charles seemed to triumph over his enemies with more ease the more numerous they were. The Russians were defeated so fast, that they were all dispersed before one party had notice of the misfortunes of another. The defeating an army of 40,000 men scarcely obstructed the march of the Swedes, while their astonished enemies looked upon these actions as the effects of witchcraft, and imagined that the king of Sweden had dealings with infernal spirits. With these apprehensions they fled beyond the Boristhenes, leaving the unhappy Augustus to his ill fate. Schullemburg, with all his skill and experience, succeeded no better. The Swedish general Renschild engaged and defeated him in half an hour, though the Swedes were vastly inferior in number, and their enemies posted in a most advantageous situation. Nothing could be more complete than this victory. Whole regiments of Saxons threw down their arms, and begged their lives in the most suppliant posture. Six thousand were slain in the field, and 7000 taken prisoners. Thirty-six pieces of cannon, 11,000 muskets, 40 pair of colours and standards, with all the Saxon baggage, fell into the hands of the Swedes: and the consequences were still more important; for now a passage was opened into Saxony, and Augustus seemed to be in as great danger of losing his hereditary dominions as he had been of losing Poland. This extraordinary victory, indeed, is said to have been owing to a panic which seized the troops of Schullemburg: however, it was looked upon with admiration, and thought to make the renown of Renschild equal to that of his sovereign. Charles himself was jealous, and could not help exclaiming, "Surely Renschild will not compare himself with me!" But the cruelty of this general sullied his reputation; for six hours after the engagement, he caused 1000 Russians to be massacred in cold blood, to revenge, as he said, the cruelties they had committed in Poland.

Soon after this victory, which was gained on the 12th of February 1706, Charles entered Saxony at the head of 24,000 men. The diet at Ratisbon declared him an enemy to the empire if he crossed the Oder. But to this declaration no regard was paid. Charles pursued his march; while Augustus was reduced to the condition of a vagrant in Poland, where he possessed not a single town besides Cracow. Into this city he threw himself with a few Saxon, Polish, and Russian regiments, and began to erect some fortifications for its defence; but the approach of the Swedish general Meyerfeldt, and the news of the invasion of Saxony, disconcerted all his measures, and threw him into despair. The Russians indeed were his faithful allies; but he dreaded

F f

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Sweden.

174
Augustus
begs for
peace on
any terms.

175
Charles's
answer.

176
Augustus,
in conjunc-
tion with
the Rus-
sians, de-
feats and
takes pri-
soner a
whole Swe-
dish army;

177
But is obli-
ged to re-
sign the
crown of
Poland.

* See the
article *Pat-
kul*.

178
Czar Peter
complains
to all the
states in
Europe.

179
Invades Po-
land, and
formally
deposes Sta-
nislus.

ed them almost as much as the Swedes: so that he was reduced to the necessity of writing a letter to Charles with his own hand, begging for peace on whatever terms he thought proper to grant. However, as he was then at the mercy of the Russians, this transaction was concealed with the greatest care. His emissaries were introduced to the Swedish court in the night-time; and being presented to Charles, received the following answer: That king Augustus should for ever renounce the crown of Poland, acknowledge Stanislaus, and promise never to reascend the throne, should an opportunity offer; that he should release the princes Sobieski, and all the Swedish prisoners made in the course of the war; surrender Patkul, at that time resident at his court as ambassador for the Czar of Muscovy, and stop proceedings against all who had passed from his into the Swedish service. These articles Charles wrote with his own hand, and delivered to count Piper, ordering him to finish them with the Saxon ambassadors.

Augustus all this time was obliged to continue a show of war, though he had neither ability nor inclination to carry it on. He was joined by prince Menzikoff with 30,000 Russians; which obliged him, contrary to his inclination, to come to an engagement with Meyerfeldt, who commanded 15,000 men, one half of whom were Swedes. As at this time no disparity of numbers whatever was reckoned an equivalent to the valour of the Swedes, Meyerfeldt did not decline the combat, though the army of the enemy was four times as numerous as his own. With his countrymen he defeated the enemy's first line, and was on the point of defeating the second, when Stanislaus, with the Poles and Lithuanians, gave way. Meyerfeldt then perceived that the battle was lost; but he fought desperately, on purpose to avoid the disgrace of a defeat. At last, however, he was oppressed by numbers, and forced to surrender; suffering the Swedes, for the first time, to be conquered by their enemies. The whole army were taken prisoners excepting major-general Krassau; who having repeatedly rallied a body of horse formed into a brigade, at last broke through the enemy, and escaped to Polesna. — Augustus had scarce sung *Te Deum* for this victory, when his plenipotentiary returned from Saxony with the articles of the treaty above mentioned. The king hesitated and scrupled, but at last signed them; after which he set out for Saxony, glad at any rate to be freed from such an enemy as the king of Sweden, and from such allies as the Russians.

The Czar Peter was no sooner informed of this extraordinary treaty, and the cruel execution of his plenipotentiary Patkul*, than he sent letters to every court in Christendom, complaining of this gross violation of the law of nations. He intreated the emperor, the queen of Britain, and the States-General, to revenge this insult on humanity. He stigmatized the compliance of Augustus with the opprobrious name of *pussillanimity*; exhorted them not to guarantee a treaty so unjust, but to despise the menaces of the Swedish bully. So well, however, was the prowess of the king of Sweden known, that none of the allies thought proper to irritate him, by refusing to guarantee any treaty he thought proper. At first, Peter thought of revenging Patkul's death by massacring the Swedish prisoners at Moscow; but from this he was soon deterred, by remembering that Charles had many more Russian prisoners than he had of Swedes. Giving over thoughts of revenging himself in this way, therefore, in the year 1707 he entered Poland, at the head of 60,000 men. Advancing to Leopold, he made himself master of that city, where he assembled a diet and solemnly deposed Stanislaus with the same ceremonies which had been used with regard to Augustus. The country was now reduced to the most miserable situation; one party, through

fear, adhered to the Swedes; another was gained over, or forced by Peter to take part with him: a violent civil war took place between the two, and great numbers of people were butchered, while cities, towns, and villages, were laid in ashes by the frantic multitude. The appearance of a Swedish army under king Stanislaus and general Lewenhaupt put a stop to these disorders, Peter himself not caring to stand before such enemies. He retired, therefore, into Lithuania, giving as the cause of his retreat, that the country could not supply him with provisions and forage necessary for so great an army.

In the mean time Charles had taken up his residence in Saxony, where he gave law to the court of Vienna, and in a manner intimidated all Europe. He declared himself the protector of the Protestant interest in Germany, particularly of the emperor's Protestant subjects in Silesia. He desired, or rather *commanded*, the emperor to renew and confirm to them all the liberties granted by the treaties of Westphalia, but since that time reclaimed or eluded at the treaty of Ryswick. The emperor durst not refuse; and upwards of 100 churches were given to the Protestants. On this occasion the emperor is reported to have said, that "had Charles desired him to become a Lutheran, he did not know whether he could have refused." One would indeed have imagined that Charles had some thoughts of converting, or at least dethroning, the Pope himself; for being incensed at the constant opposition of the court of Rome, whose weakness and intrigues he despised, he one day told the emperor's minister, that "the Swedes had conquered Rome before now, and he might one day demand an inventory of the effects left there by queen Christina." At last, satiated with the glory of having dethroned one king, set up another, and struck all Europe with terror and admiration, Charles began to evacuate Saxony, in pursuit of his great plan, the dethroning Czar Peter, and conquering the vast empire of Russia. While the army was on full march in the neighbourhood of Dresden, he took the extraordinary resolution of visiting king Augustus with no more than five attendants. Though he had no reason to imagine that Augustus either did or could entertain any friendship for him, he was not uneasy at the consequences of thus putting himself entirely in his power. He got to the palace door of Augustus before it was known that he had entered the city. General Fleming, having seen him at a distance, had only time to run and inform his master. What might be done in the present case immediately occurred to the minister; but Charles entered the elector's chamber in his boots before the latter had time to recover from his surprise. He breakfasted with him in a friendly manner, and then expressed a desire of viewing the fortifications. While he was walking round them, a Livonian, who had formerly been condemned in Sweden, and served in the troops of Saxony, thought he could never have a more favourable opportunity of obtaining pardon. He therefore begged of king Augustus to intercede for him, being fully assured that his majesty could not refuse so slight a request to a prince in whose power he then was. Augustus accordingly made the request; but Charles refused it in such a manner, that he did not think proper to ask it a second time. Having passed some hours in this extraordinary visit, he returned to his army, after having embraced and taken leave of the king he had dethroned.

The armies of Sweden, in Saxony, Poland, and Finland, now exceeded 70,000 men; a force more than sufficient to have conquered all the power of Muscovy, had they met them on equal terms. Peter, who had his army dispersed in small parties, instantly assembled it on receiving notice of the king of Sweden's march, was making all possible preparations

180
Retires into
Lithuania.

181
Imperious
behaviour
of Charles.

182
Submissive
behaviour
of the em-
peror to
him.

183
Charles vi-
sits king
Augustus.

184
Marches
against the
Russians.

Sweden. tions for a vigorous resistance, and was on the point of attacking Stanislaus, when the approach of Charles struck his whole army with terror. In the month of January 1708 he passed the Niemen, and entered the south gate of Grodno just as Peter was quitting the place by the north gate. Charles at this time had advanced to some distance before the army at the head of 600 horse. The Czar having intelligence of his situation, sent back a detachment of 2000 men to attack him: but they were utterly defeated; and this disappointment was followed by the total evacuation of Lithuania. The king pursued his flying enemies in the midst of snow and ice, over mountains, rivers, morasses, and through almost every obstacle that could be surmounted by human power. He had foreseen all difficulties, and determined to surmount them all. As he knew that the country could not furnish provisions sufficient for the subsistence of his army, he had provided a great quantity of biscuit, on which his men chiefly subsisted till they came to the banks of the Berezine, in view of Borislow. Here the Czar was posted, and Charles designed to bring him to a battle; after which he could penetrate with the greater ease into Russia. Peter, however, did not think proper to come to an action; but retreated towards the Boristhenes, whither he was pursued by Charles as soon as he had refreshed his army. The Russians had destroyed the roads and desolated the country; nevertheless the Swedish army advanced with great celerity, and in their way defeated 20,000 of the enemy, though entrenched to the teeth. This victory, considering the circumstances in which it was gained, was one of the most glorious the Swedes ever obtained. The memory of it is preserved by a medal struck in Sweden, with this inscription, *Sylvæ, Paludes, Aggeres, Hostes, victi*.

185 Defeats and drives them out of Lithuania.
186 Gains a remarkable victory.
187 The Czar sues for peace, but receives an haughty answer.
188 Another desperate engagement.
189 Charles arrives within 100 leagues of Moscow, but finds the roads impassable.

When the Russians had repassed the Boristhenes, which separates Poland from Muscovy, the Czar, finding himself closely pursued by an enemy with whom he was not able to cope, determined at last to propose peace. Proposals were accordingly made; but Charles returned no other answer than that he would treat at Moscow; which being reported to Peter, he coolly replied, "My brother Charles affects to play Alexander, but he will not find in me a Darius." However, he did not think proper to venture an engagement, but continued his retreat; and Charles pursued so close, that he was daily skirmishing with the rear of the enemy. In these actions the Swedes had generally the advantage, though in the main these victories proved detrimental, by weakening the army in a country where it was impossible to recruit. Near Smolensko, the king, with only six regiments, defeated a body of 10,000 horse and 6000 Calmucks. In this engagement he was exposed to the utmost danger, the enemy having separated him from his troops. With one regiment only, he fought with such fury as dispersed the enemy, and drove them before him, at the time they thought themselves sure of taking him prisoner. Two aids-de-camp that fought near him were killed; his horse was killed, as was also an equerry while he presented another. The enemy had broke through the regiment, and got quite up to the king; who is said to have on this occasion killed 12 men with his own hand without receiving a wound.

By the 3d of October 1708 Charles was within 100 leagues of Moscow; but the Czar had made the roads impassable, either by laying them under water, digging deep ditches, or covering them with the wood of whole forests. He had also destroyed the villages on every side, and taken away every possibility of subsisting an army. The season was also far advanced; the intense severe weather was approaching; so that the Swedes were threatened with all the miseries of cold and famine, at the same time that they were exposed to the attacks of an enemy greatly superior in num-

ber, who, from their knowledge of the country, had almost constant opportunities of harassing and attacking them by surprise. For these reasons the king resolved to pass thro' the Ukrain, where Mazeppa, a Polish gentleman, was general and chief of the nation. Mazeppa having been affronted by the Czar, readily entered into a treaty with Charles, whom he promised to assist with 30,000 men, great quantities of provisions and ammunition, and with all his treasures, which were immense. The Swedish army advanced towards the river Disna, where they had to encounter the greatest difficulties; a forest above 40 leagues in extent, filled with rocks, mountains, and marshes. To complete their misfortunes, they were led 30 leagues out of the right way; all the artillery was sunk in bogs and marshes; the provision of the soldiers, which consisted of biscuit, was exhausted; and the whole army spent and emaciated when they arrived at the Disna. Here they expected to have met Mazeppa with his reinforcement; but instead of that, they perceived the opposite banks of the river covered with a hostile army, and the passage itself almost impracticable. Charles, however, was still undaunted; he let his soldiers by ropes down the steep banks; they crossed the river either by swimming or on rafters hastily put together; drove the Russians from their post, and continued their march. Mazeppa soon after appeared, having with him about 6000 broken remains of the army he had promised. The Russians had got intelligence of his designs, defeated and dispersed his adherents, laid his towns in ashes, and taken all the provisions collected for the Swedish army. However, he still hoped to be useful by his intelligence in an unknown country; and the Cossacks, out of revenge, crowded daily to the camp with provisions.

Greater misfortunes still awaited the Swedes. When Charles entered the Ukrain, he had sent orders to general Lewenhaupt to meet him with 15,000 men, 6000 of whom were Swedes, and a large convoy of provisions. Against this detachment Peter now bent his whole force, and marched against him with an army of 65,000 men. Lewenhaupt had received intelligence that the Russian army consisted only of 24,000; a force to which he thought 6000 Swedes superior, and therefore disdained to entrench himself. A furious contest ensued; in which the Russians were defeated with the loss of 15,000 men. The Swedes continued their march; but, by the treachery of their guide, were led into a marshy country, where the roads were made impassable by deep ditches and trees laid across. Here he was again attacked by the Czar with his whole army. Lewenhaupt had sent a detachment of two battalions to dispute the passage of the enemy over a morass; but finding they were likely to be overpowered, he marched at the head of the whole infantry to their relief. Another desperate battle ensued; when at last the Russians were put in disorder, and on the point of being totally defeated, when the Czar gave orders to the Cossacks and Calmucks to fire upon all the Russians who fled. "Even kill me (said he) if I should be so cowardly as to turn my back." On this the battle was renewed with great vigour; but notwithstanding these positive orders, and the example of the Czar himself, the Russians were a third time put in disorder, after losing 6000 men, when general Bayer arrived with a strong reinforcement of fresh Russian troops. The engagement was again renewed, and continued without intermission till night. The Swedes took possession of an advantageous post; but were next morning attacked by the Russians. Lewenhaupt had formed a kind of rampart of his waggons, but was obliged to set fire to them, in order to prevent their falling into the hands of the enemy, and at the same time to cover his retreat by the smoke. The Russians, however, came soon enough

Sweden.
190 Resolves to pass thro' the Ukrain.

191 Meets with great difficulties.

192 Defeats the Russians, and is joined by Mazeppa's great distress.

193 Desperate encounters between General Lewenhaupt and the Russians.

194 All the Swedish provisions burnt or taken by the Russians.

Sweden. enough to save 5000 waggons of those provisions designed for the distressed Swedes. A strong detachment was sent to pursue Lewenhaupt; but so terrible did he appear, that the Russian general offered him an honourable capitulation. This was refused with disdain; and the battle renewed with the same vigour as before. The Swedes, though reduced to 4000, again defeated their enemies, and killed 5000 on the spot. After this, Lewenhaupt was suffered to pursue his march without molestation, but also without cannon or provisions. Prince Menzikoff, indeed, was detached to harass him; but such was the formidable appearance of the Swedes even in their distress, that he was afraid to attack them: so that at last the 4000 arrived safe in the camp of Charles, after having killed upwards of 30,000 of the enemy on their march.

195
Lewenhaupt joins the main army in spite of all opposition.

196
Extreme distress of the Swedes.

197
Charles besieges Pultowa.

198
A detachment of 8000 Swedes entirely defeated and cut off.

199
The Swedes harassed by an army of 70,000 Russians.

200
Battle of Pultowa.

This, we may say, was the last effort of Swedish valour. The difficulties they had now to undergo exceeded what human nature could bear; yet still they hoped, by constancy and courage, to overcome every obstacle. In the severest winter known for a long time even in Russia, they made long marches, clothed like savages in the skins of wild beasts; all the draught-horses perished; thousands of soldiers dropped dead with cold and hunger: so that by the month of February 1709, the whole army was reduced to 18,000 Swedes. Amidst numberless difficulties these penetrated at last to Pultowa, a town on the eastern frontier of the Ukrain, where the Czar had laid up magazines; and of these Charles resolved to get possession. Mazeppa advised the king to invest the place, in consequence of his having correspondence with some of the inhabitants, by whose means he hoped it would be surrendered. However, he was deceived; the besieged made an obstinate defence, the Swedes were repulsed in every assault, and 8000 of them were defeated, and almost entirely cut off, in an engagement with a party of Russians. To complete his misfortunes, Charles received a shot from a carabine in his heel, which shattered the bone. For six hours after he continued calmly on horseback, giving orders, till he fainted with the loss of blood; after which he was carried into his tent. It was imagined that amputation would be necessary, as the wound had already begun to mortify; but one Newman undertook to save the limb. It was told the king that deep incisions would be necessary. "Fall to work then (said he), cut boldly, and fear nothing." He held out his leg while the operation was performing; never changed countenance; and while the dressing was laid on, ordered an assault for the next morning.

For some days the Czar, with an army of 70,000 men, had lain at a small distance, harassing the Swedish camp, and cutting off the convoys of provision; but now intelligence was received, that he was advancing as if with a design of attacking the lines. In this situation, Charles, wounded, distressed, and almost surrounded by enemies, is said to have, for the first time, assembled a grand council of war; the result of which was, that it was expedient to march out and attack the Russians. Voltaire, however, totally denies that the king relaxed one jot of his wonted obstinacy and arbitrary temper: but that, on the 7th of July, he sent for general Renschild, and told him, without any emotion, to prepare for attacking the enemy next morning.

The 8th of July 1709 is remarkable for the battle which decided the fate of Sweden. Charles having left 8000 men in the camp to defend the works and repel the sallies of the besieged, began to march against his enemies by break of day with the rest of the army, consisting of 26,000 men, of whom 18,000 were Cossacks. The Russians were drawn up in two lines behind their intrenchments, the horse in

front, and the foot in the rear, with chains to suffer the horse to fall back in case of necessity. General Slippenbach was dispatched to attack the cavalry; which he did with such impetuosity, that they were broken in an instant. However, they rallied behind the infantry, and returned to the charge with such vigour, that they disordered the Swedes in their turn, and took Slippenbach prisoner. Charles was now carried in his litter to this scene of confusion. The troops were animated by his presence, and returned to the charge; the battle became doubtful, when general Creuk was dispatched by Charles to attack the enemy in flank. Creuk mistook his way, or, according to others, who had the best opportunities of information, was bribed by Russian gold, which occasioned the loss of the battle. Peter now dispatched prince Menzikoff with a strong detachment, to post himself between the Swedes and Pultowa, to cut off their communication with their camp, and to fall upon their rear. He executed his orders with great success; cut off a corps de reserve of 3000 men; and thus decided the fortune of the day. The king, however, had ranged his remaining troops in two lines; the foot in the centre, and the horse in the two wings. They had already been twice rallied, and were now attacked with fury on all sides. Charles, in his litter, with his sword drawn in one hand, and a pistol in the other, seemed to be everywhere present. New misfortunes, however, awaited him. A cannon ball killed both horses in the litter; and scarce were others put in their place, when a second broke the litter itself in pieces, and overturned the king. The soldiers now believing him killed, fell back in consternation. The first line was broke, and the second fled. Charles did every thing in his power to restore order; but the Russians pressed so hard, that rallying was impossible, especially as powder was also wanting. Renschild and several other general officers were taken prisoners; and the king himself must have fallen into the hands of the enemy, had not count Poniatowsky drawn up 500 horse, surrounded the royal person, and with desperate fury broke through ten regiments of the enemy. With these the king arrived on the banks of the Boristhenes. The Russians forced the Swedish camp, where they found six millions in specie; but could not hinder Lewenhaupt, with 4000 foot and all the remaining cavalry, from retreating to the banks of the Boristhenes. This, however, availed them but little; for being pursued by prince Menzikoff, they were obliged, for want of boats or bridges, to surrender at discretion. Charles fled in a mean calash, attended by a little troop inviolably attached to his person, some on foot, and some on horseback. They were obliged to cross a sandy desert, where neither herb nor tree was to be seen, and where the burning heat and want of water were more intolerable than the extremities of cold they had formerly suffered. The whole had almost perished for want of water, when a spring was fortunately discovered; after which they reached Oczakow, a town in the Turkish dominions, the bashaw of which supplied the king with every necessary. It was some time, however, before boats could be got ready for transporting the whole of the king's attendants; by which accident 500 Swedes and Cossacks fell into the hands of the enemy. This loss affected him more than all his other misfortunes. He shed tears at seeing across the river Bog the greater part of his few remaining friends carried into captivity, without having it in his power to assist them. The bashaw waited upon him to apologize for the delay, and was severely reprimanded by Charles, as if he had been his own subject.

The king remained but a few days at Oczakow, when the serasquier of Bender sent an aga to compliment him on his arrival in the Turkish dominions, and to invite him to that city.

Sweden.

201
The Swedes entirely defeated.

202
The camp taken, and the Swedish army almost all killed or taken.

203
Charles arrives safe in Turkey.

Sweden. city. Here he was treated with the utmost hospitality: the Turks practised to its utmost extent their generous maxim of regarding as sacred the persons of unfortunate princes who had taken shelter in their dominions: and perhaps regarded him, notwithstanding his misfortunes, as an ally that might be useful to themselves against the Russians. Every one, indeed, regarded him in his distress. The French king offered him a safe passage from the Levant to Marseilles, from whence he might easily return to his own dominions. But Charles was too obstinate to receive advice. Puffed up with the notion of imitating Alexander the Great, he disdained to return except at the head of a numerous army; and he yet expected, by means of the Turks, to dethrone his adversary the Czar. Negotiations for this purpose, indeed, were carried on in the Turkish divan; and it was proposed to escort Charles with a numerous army to the frontiers of Poland: but the revolution which took place there quickly put an end to all such projects. Augustus thought himself no longer bound to observe the treaty which he had made, than Charles was at hand to force him to it. After the battle of Pultowa, therefore, he entered Poland, and took every measure, in concert with the Czar, for the recovery of his kingdom. Stanislaus was not able to stand before such enemies, but was obliged to leave his dominions and fly to Bender, in the disguise of a Swedish officer, in order to share the fortune of Charles.—It was not in Poland alone that the Swedish affairs began to suffer in consequence of the defeat at Pultowa. The Danes quickly invaded the province of Schonen with an army of 13,000 foot and 2500 horse. Only 13,000 Swedish forces remained to defend all the territories possessed by Charles in Germany; and of these only a small part were allotted for the defence of Schonen. The regency of Sweden, however, exerted themselves to the utmost to repel this ungenerous invasion; and having collected an army of 12,000 militia and 8000 regulars, dispatched them under general Steenbock into Schonen. Some Saxon troops were incorporated in this army; and among these a prodigious desertion took place, which the general found it impossible to prevent; and thus the Danes gained several advantages, and at last took Christianstadt. Their insolence on this success was so great, that the Swedes demanded to be instantly led against them. Here the good fortune of Sweden seemed once more to revive. The Danes were driven from a very strong situation, with the loss of 8000 killed and taken prisoners, besides a vast number wounded. The king received the intelligence of this victory with the greatest exultation; and could not help exclaiming, "My brave Swedes, should it please God that I once more join you, we shall conquer them all!"

In the mean time, Charles, by means of his agents the count Poniatowski and the Sieur Neugebar, used his utmost efforts to procure a rupture between the Porte and Russia. For a long time the money bestowed by Peter on the vizirs and janisaries prevailed; but at last, in 1711, the grand signior, influenced by his mother, who was strongly in the interest of Charles, and had been wont to call him *her lion*, determined to avenge his quarrel with Peter. He therefore gave orders to the vizir to fall upon the Russians with an army of 200,000 men. The vizir promised obedience; but at the same time professed his ignorance in the art of war, and dislike to the present expedition. The khan of Crim Tartary, who had been gained over by the reputation and presents of the king of Sweden, had orders to take the field

Sweden. with 40,000 of his men, and had the liberty of assembling his army at Bender, that Charles might see that the war was undertaken upon his account. The Czar, on these news, left the siege of Riga, where he had continued for some months; and with 24,000 men entered Moldavia, where he was joined by Cantemir a vassal of the Porte. The vizir marched against him with a prodigious army, and, through the negligence of the Czar, cooped him up in such a manner that he could neither advance nor retreat. In this desperate situation, he perceived that he was now in as bad a situation as Charles at Pultowa; and gave orders for breaking through the enemy with fixed bayonets. The desponding spiritless soldiers, however, were little disposed to execute these orders; when Catharine, wife to the czar, without his knowledge, set on foot a treaty with the vizir; and having soon obtained his consent, had the peace signed in six hours; by which means, in all probability, the whole Russian army was saved.

The new treaty was most violently opposed by count Poniatowski and the khan of Tartary. The former had made the king acquainted with the situation of both armies; on which he instantly set out from Bender, filled with the hopes of fighting the Russians, and taking ample vengeance. Having ridden 50 leagues post, he arrived at the camp just as the czar was drawing off his half-famished troops. He alighted at Poniatowski's tent; and being informed of particulars, instantly flew in a rage to the vizir, whom he loaded with reproaches, and accused of treachery. Recollecting himself, however, he proposed a method by which the fault might be remedied; but finding his proposal rejected, he posted back to Bender, after having by the grossest insults showed his contempt of the vizir.

The violent behaviour of Charles did not promote his interest. The vizir perceived that his stay in Turkey might prove fatal to himself; and therefore determined to get him out of the country as soon as possible, either by fair means or foul. Succeeding vizirs adopted the same plan; and at last the grand signior himself wrote a letter to the king, in which he desired him to depart by next winter, promising to supply him with a sufficient guard, with money, and every thing else necessary for his journey. Charles gave an evasive answer, and determined to procrastinate his journey, as well to gratify his own stubborn temper, as because he discovered a correspondence between Augustus and the khan of Tartary, the object of which, he had reason to believe, was to betray him to the Saxons. When he was therefore again pressed to fix the day of his departure, he replied, that he could not think of going before his debts were paid. Being asked how much was necessary for this purpose, he replied, 1000 purses (A). Twelve hundred purses were instantly sent to the serasquier at Bender, with orders to deliver them to the king of Sweden, but not before he should have begun his journey. By fair promises, however, Charles persuaded him to part with the money; after which, instead of setting out, he squandered away his treasure in presents and gratifications, and then demanded 1000 purses more before he would set out. The serasquier was astonished at this behaviour. He shed tears; and, turning to the king, told him, that his head would be the forfeit of having obliged him with the money. The grand signior, on being acquainted with this shameful behaviour of Charles, flew into a rage, and called an extraordinary divan, where he himself spoke, a thing very unusual for the Turkish monarchs. It was unanimously agreed that such a trouble-
some

(A) Each purse contained 30 sequins.

some guest ought to be removed by force should other means fail. Orders were therefore positively sent to Charles to depart; and, in case of refusal, to attack him in his quarters. Nothing could equal his obstinacy on this occasion: in spite of the menaces of his enemies, in spite of the intreaties of his friends, he persisted in his resolution; and at last determined to resist, with 300 Swedes, being all the attendants he had, an army of 20,000 janisaries well armed and furnished with cannon. At length he was attacked in good earnest; though it must be owned, that even in this extremity, the Turks showed their regard to him, and were tender of his life, which the king did not return at all in a similar manner. Most of the Swedes surrendered at once, perhaps as thinking it the only method of saving the king's life. This misconduct, however, had a quite contrary effect. Charles became the more obstinate, the more desperate his affairs seemed to be. With 40 menial servants only, and the generals Hord and Dardorff, he determined to defend himself to the last extremity. Seeing his soldiers lay down their arms, he told the generals, "We must now defend the house. Come, (adds he with a smile), let us fight *pro aris et focis*." The house had been already forced by the Tartars, all but a hall which was near the door, and where his domestics had assembled themselves. Charles forced his way through the janisaries, attended by the generals Hord and Dardorff, joined his people, and then barricaded the door. The moment he entered, the enemy, who were in the house, threw down their booty, and endeavoured to escape at the windows. Charles pursued them from room to room with much bloodshed, and cleared the house in a few minutes. He then fired furiously from the windows, killed 200 of the Turks in a quarter of an hour, so that the bashaw who commanded them was at length forced to set the house on fire. This was done by arrows with lighted matches shot into the roof; but Charles, instead of quitting it, gave orders for extinguishing the fire, in which he himself assisted with great diligence. All efforts, however, were vain: the roof fell in; and Charles, with his few faithful companions, was ready to be buried in the ruins. In this extremity one called out, that there was a necessity for surrendering. "What a strange fellow! (cries the king), who would rather be a prisoner with the Turks than mix his ashes with those of his sovereign." Another had the presence of mind to cry out, that the chancery was but 50 paces off, had a stone roof, and was proof against fire. Pleased with the thoughts of again coming to blows, the king exclaimed, "A true Swede! Let us take all the powder and ball we can carry." He then put himself at the head of his troops, and sallied out with such fury that the Turks retreated 50 paces; but falling down in the hurry, they rushed in upon him, and carried him by the legs and arms to the bashaw's tent.

This extraordinary adventure, which favours not a little of insanity, happened on the 12th of February 1713. He was now kept prisoner, with all his retinue; and in this situation he was visited by the unfortunate Stanislaus. The latter, as we have already observed, came in the disguise of a Swedish officer, and had indeed served in the Swedish army in Pomerania, for which reason he was arrested in the Turkish dominions; but being known at Bender, notice was sent to the bashaw who was conducting the king of Sweden to Adrianople. The bashaw communicated the news to Baron Fabricius, a favourite of Charles, who immediately imparted it to the king. "Dear Fabricius, (says this inflexible monarch), run and tell him never to make peace with Augustus; we shall soon have a change in our affairs."

Such were the considerations that still occurred to the mind of Charles; however, at last he seemed inclined to

submit to his fate, and began seriously to think of returning to his kingdom, now reduced to the most deplorable situation. His habitation was now fixed at Demotica, a small town about six leagues from Adrianople. Here he was allowed provisions for his own table and those of his retinue; but only 25 crowns a-day in money, instead of 500 which he had received at Bender. During his residence here he received a deputation from Hesse-Cassel, soliciting his consent to the marriage of the landgrave with Eleonora princess royal of Sweden; to which he readily agreed: a deputation was also sent him by the regency of Sweden, requesting that he would prepare for returning to his own dominions, which were ready to sink under a ruinous war in his absence. What determined him, however, more than any thing to hasten his return, was the following accident. The new grand vizir Ibrahim Molla, having for private reasons determined to come to a rupture with the czar, invited Charles to a conference, in the style and with the familiarity of an equal. Charles was so much chagrined at this indignity, that he sent his chancellor Mullern to meet the vizir, with a pretence that he was sick. To avoid giving offence to this minister, Charles was obliged to keep his bed during his residence at Demotica, which was for 10 months after. At last, this vizir being strangled, and the Swedish interest at the Porte thereby entirely ruined, he determined to quit Turkey at all events. His departure was to be negotiated by his favourite Grothusen, whom he vested with the character of ambassador extraordinary; sending him to Adrianople with a train of 14 persons richly dressed. To equip this retinue the king was reduced to the most mortifying shifts, and to the necessity of borrowing money from usurers at 50 per cent. The great object was, to obtain from the vizir money and a passport. Grothusen was received with all the respect due to his rank; but the vizir started difficulties. With regard to the passport, he said, it could be of no use until the consent of the court of Vienna was first obtained; and as to money, he said, "his master knew how to give when he thought proper, but it was beneath his dignity to lend; that the king should have every necessary provided for his journey, and possibly the Porte might make some pecuniary present, but he would not have it expected." The imperial minister, however, removed every difficulty with regard to the passport, by granting it in the most full and ample manner, in the name of the emperor, the princes and states of Germany. He sent also a present to the king, consisting of a tent of scarlet richly embroidered with gold; a sabre, the handle of which was studded with jewels; and eight fine horses richly caparisoned. Money, the article most wanted, was entirely forgotten; however, the day was fixed for Charles's departure, and the vizir appointed 60 carriages loaded with all kinds of provisions, and several companies of janisaries and other troops to attend him to the frontiers of Transylvania.

On the 14th of October 1714, Charles quitted his bed at Demotica, and set out for Sweden. All the princes through whose territories he was to pass, had given orders for his entertainment in the most magnificent manner; but the king, perceiving that these compliments only rendered his imprisonment and other misfortunes more conspicuous, suddenly dismissed his Turkish attendants, and assembling his own people, bid them take no care about him, but make the best of their way to Stralsund. After this he set out post, in the habit of a German officer, attended only by Colonel During. Keeping the by-roads through Hungary, Moravia, Austria, Bavaria, Wirtemberg, the Palatinate, Westphalia, and Mecklenburg, he arrived on the 21st of November at midnight before the gates of Stralsund. Being unknown, he was admitted with difficulty; but being soon recognized by

213
The Turks
resolve to
force him
to depart.

214
His desperate
resolution to re-
sist.

215
Is abandoned
by all his follow-
ers except
40.

216
Fights like
a madman,
but is taken
prisoner
with all his
followers.

217
Stanislaus
arrested in
Turkey.

218
Extreme
infatigability
of Charles.

Sweden.
219
Begins to
think of
returning
to his do-
minions.

220
Obliged, by
his unfea-
sible
pride, to
keep his
bed for 10
months.

221
Sends an
ambassador
to the Porte,
who is not
very fa-
vourably
received.

222
Sets out for
Sweden.

223
Dismisses
his retinue,
and pro-
ceeds with
only one
attendant.

Sweden. by the governor, the greatest tokens of joy were shown all over the town. In the midst of the tumult Charles went to bed. He had been booted for 16 days, and now his legs were swelled to such a degree that it was necessary to cut his boots off. Having slept for some hours, he arose, reviewed his troops, and gave orders for renewing the war with redoubled vigour.

Sweden was now in the greatest distress. We have already mentioned, that on the news of the defeat at Pultowa, the Danes had invaded Schonen, but were defeated by General Steenboek. This victory, however, did not put an end to the war. On the contrary, the kings of Denmark and Poland, with the czar of Muscovy, entered into stricter bonds of amity than ever. They dreaded the return of Charles to his own dominions, and apprehended that numberless victories would soon efface the remembrance of Pultowa. They determined, therefore, to make the best use of their time; and perhaps Charles never took a more imprudent resolution than obstinately to remain so long in the Turkish dominions. The kings of Denmark and Poland invaded Pomerania; but after laying siege in vain to Stralfund, Wismar, and other places, they were obliged to retire with disgrace into winter-quarters. In 1712, the king of Denmark invaded and reduced Bremen and Verden; but the same year met with a terrible defeat from Steenboek, with the loss of a vast number killed and wounded, and almost all their artillery taken. The following year, however, this general being pursued, and surrounded by the united forces of the Russians, Danes, and Saxons, was obliged to throw himself into the neutral town of Tommingen; where he was besieged, and obliged to surrender at discretion, with his whole army.

The consequence of this disaster was an invasion of Finland by the czar; which province he totally reduced, after defeating the Swedes in several engagements. Indeed, the Swedish forces were now so much reduced, that they were unable to cope with almost any enemy. The return of Charles, however, seemed to give new life to the whole nation. Though the number of inhabitants was visibly diminished, the levies he had ordered were completed in a few weeks: but the hands left to cultivate the earth consisted of the infirm, aged, and decrepid; so that a famine was threatened in consequence of the military rage which had seized all the youth of the kingdom.

The presence of Charles did not now produce those consequences which the allies had feared. The kingdom was too much reduced to be able to furnish the necessary supplies of men and money; and though the king's courage and military skill were not in the least diminished, the efforts he made, instead of restoring Sweden to its splendour, served entirely to ruin it. In 1715, Prussia declared against him, on account of his demanding back the town of Stetin, which that monarch had seized. To complete his embarrassment, the elector of Hanover, George I. of Britain, also became his enemy. The forces of Denmark, Prussia, Saxony, and Hanover, joined to invest Wismar, while a body of 36,000 men formed the siege of Stralfund; at the same time that the czar, with a fleet of 20 large ships of war, and 150 transports, carrying 30,000 men, threw every part of the Swedish coast into the greatest consternation. The heroism of Charles could not prevail against so many enemies; yet he was still so dreadful, that the prince of Anhalt, with 12,000 brave troops, did not think himself a match for this furious enemy when at the head of only 2000, till he had entrenched his army behind a ditch, defended by chevaux de frize. It appeared, indeed, that his precaution was not unnecessary; for in the night Charles with his men clambered up the ditch, and attacked the enemy in his usual manner. Numbers, however, at last prevail-

ed; and Charles was obliged to retire, after having seen his favourite Grothusen, General Dardorff and During, the companions of his exile, killed by his side, he himself being wounded in the breast.

This rash attempt was made in order to save Rugen, Stralfund from whence the town of Stralfund was supplied with provisions. The place was well fortified, and garrisoned with 9000 men, with Charles himself at their head; but nothing could resist the efforts of the enemy. The houses were laid in ashes by the bombs; the walls miserably shattered, and large breaches made in them by the cannon; so that by the 17th of December it was proposed to give the assault. The attack on the horn-work was desperate: the enemy was twice repulsed; but at last, by dint of numbers, effected a lodgment. The next day Charles headed a sally, in which he dealt terrible destruction among the besiegers, but was at length overpowered and obliged to retreat into the town. At last his officers, apprehending that he must either fall into the hands of the enemy, or be buried in the ruins of the place, intreated him to retire. A retreat, however, was now almost as dangerous as to remain in the town, on account of the fleets of the enemy with which the sea was covered; and it is thought that this very circumstance induced the king to consent to it. Setting out, therefore, in a small boat with sails and oars, he passed all the enemy's ships and batteries, and arrived safe at Ystedt in Schonen.

To revenge himself for these losses, Charles invaded Norway with an army of 25,000 men. The Danes were everywhere defeated and pursued with that vigour for which the king of Sweden was so remarkable; but strong reinforcements arriving from Denmark, and provisions failing, he was at last obliged to retire, and evacuate the country. Soon after this the Swedes lost Wismar; but when every thing seemed to go to wreck, Baron Goertz the chief minister and favourite of Charles found means to set on foot a treaty with the czar of Muscovy, by which the most formidable of all Charles's enemies was taken off. The minister found means to work upon the inflexible and stubborn temper of Charles, by representing to him that the cession of certain provinces to Peter would induce him to assist him in his projects of again dethroning Augustus, and of replacing James on the throne of Britain; which last scheme he had projected out of revenge for the elector of Hanover having seized on the duchies of Bremen and Verden. In consequence of the conferences between the czar and Goertz, the former engaged to send into Poland an army of 80,000 men, in order to dethrone that prince whom he had so long defended. He engaged also to furnish ships for transporting 30,000 Swedes to Germany and 10,000 into Denmark. This treaty, however, was not fully ratified; and the king's death, which happened in 1718, put a final stop to all the great prospects of Sweden.

The king had resolved on the conquest of Norway before he dethroned Augustus; and as no difficulties ever deterred him, he marched his army into that cold and barren country in the month of October, when the ground was covered with frost and snow. With 18,000 men he formed the siege of Frederickshall, though the severity of the frost rendered it almost impossible to break ground. Charles, however, resolved to form trenches; and his soldiers cheerfully obeyed, digging into the ground with the same labour as if they had been piercing a rock. On the 11th of December the king visited the trenches in the midst of a terrible fire from the enemy, imagining that his men might be animated by his presence. He took his post in the most dangerous station he could choose, standing upon a gabion and leaning with his arm over the parapet, while the enemy were firing chain shot at the very spot where he stood. He was in-

treated

Sweden. treated to change his station; but he remained obstinate, as if he had been proof against cannon-bullets. At last he was seen to fall on the parapet with a deep groan. A small cannon-ball had struck him on the temple, beat in the left eye, and forced the right eye quite out of its socket; his right hand in the mean time grasped the hilt of his sword, as if he had meant to revenge the blow (c).

236
Account of
the Swedish
affairs from
the death of
Cha. XII.
to the year
1771.

Charles XII. was succeeded by his sister the princess Ulrica Eleonora, wife to the hereditary prince of Hesse. On this occasion the states took care to make a previous stipulation for the recovery of their liberties, and obliged the princess to sign a paper to this purpose before entering on the government. Their first care was to make a peace with Great Britain, which the late king intended to have invaded. The Swedes then, to prevent their farther losses by the progress of the Russian, the Danish, the Saxon, and other arms, made many great sacrifices to obtain peace from those powers. The French, however, about the year 1738, formed a dangerous party in the kingdom, under the name of the *Hets*; which not only broke the internal quiet of the kingdom, but led it into a ruinous war with Russia, by which the province of Finland was lost. Their Swedish majesties having no children, it was necessary to settle the succession; especially as the duke of Holstein was descended from the queen's eldest sister, and was, at the same time, the presumptive heir to the empire of Russia. Four competitors appeared; the duke of Holstein Gottorp, prince Frederic of Hesse-Cassel nephew to the king, the prince of Denmark, and the duke of Deux-Ponts. The duke of Holstein would have carried the election, had he not embraced the Greek religion, that he might mount the throne of Russia. The czarina interposed, and offered to restore all the conquests she had made from Sweden, excepting a small district in Finland, if the Swedes would receive the duke of Holstein's uncle, Adolphus Frederic bishop of Lubec, as their hereditary prince and successor to their crown. This was agreed to; and a peace was concluded at Abo, under the mediation of his Britannic majesty. This peace was so firmly adhered to by the czarina, that his Danish majesty thought proper to drop all resentment for the indignity done his son. The prince-successor married the princess Ulrica, third sister to the king of Prussia; and in 1751 entered into the possession of his new dignity, which proved to him a crown of thorns. Through a strange medley of affairs and views of interest, the French had acquired vast influence in all the deliberations of the Swedish senate, who of late have been little better than pensioners to that crown. The intrigues of the senators forced Adolphus to take part in the late war against Prussia: but as that war was disagreeable not only to the people, but also to the king of Sweden, the nation never made so mean an appearance; and upon Russia's making peace with the king of Prussia, the Swedes likewise made their peace, upon the terms

of leaving things as they stood at the beginning of the war. Sweden. Adolphus died dispirited in 1771, after a turbulent reign of twenty years; and was succeeded by his son Gustavus. 237 The most remarkable transaction of this reign is the revolution which took place in the government in the year 1772, by which the king, from being the most limited became one of the most despotic monarchs in Europe. Ever since the death of Charles XII. the whole power of the kingdom had been lodged in the states; and this power they had on all occasions most grievously abused. Gustavus therefore determined either to seize on that power of which they made such a bad use, or perish in the attempt. 238 The revolution was effected in the following manner. On the morning of the 19th of August 1772, a considerable number of officers, as well as other persons known to be attached to the royal cause, had been summoned to attend his majesty. Before ten he was on horseback, and visited the regiment of artillery. As he passed through the streets he was more than usually courteous to all he met, bowing familiarly to the lowest of the people. On the king's return to his palace, the detachment which was to mount guard that day being drawn up together with that which was to be relieved, his majesty retired with the officers into the guard-room. He then addressed them with all that eloquence of which he is said to have been a perfect master; and after insinuating to them that his life was in danger, he exposed to them in the strongest colours the wretched state of the kingdom, the shackles in which it was held by means of foreign gold, and the dissensions and troubles arising from the same cause which had distracted the diet during the course of fourteen months. He assured them that his only design was to put an end to these disorders; to banish corruption, restore true liberty, and revive the ancient lustre of the Swedish name, which had been long tarnished by a venality as notorious as it was disgraceful. Then assuring them in the strongest terms that he disclaimed for ever all absolute power, or what the Swedes call *sovereignty*, he concluded with these words: "I am obliged to defend my own liberty and that of the kingdom, against the aristocracy which reigns. Will you be faithful to me, as your forefathers were to Gustavus Vasa and Gustavus Adolphus? I will then risk my life for your welfare and that of my country."

The officers, most of them young men, of whose attachment the king had been long secure, who did not thoroughly perhaps see into the nature of the request his majesty made them, and were allowed no time to reflect upon it, immediately consented to every thing, and took an oath of fidelity to him.

Three only refused. One of these, Frederic Cederstrom, captain of a company of the guards, alleged he had already taken an oath to be faithful to the states, and very lately taken an oath to be faithful to the states, and consequently could not take that which his majesty then exacted. 239 Resolution of a Swedish officer.

(c) Such is the account given by Voltaire of the untimely death of this northern hero. Many persons, however, who had the best opportunities of procuring authentic information at the time, have declared that they believed he was assassinated by a Frenchman who was among his attendants. The famous earl of Peterborough, who, in his rapid marches and fearless intrepidity, bore no small resemblance to Charles XII. assured Bishop Berkeley, that he had no doubt of the Swedish monarch's having been assassinated; and Mr Wraxall, in the account of his Travels through Sweden, gives such arguments for the truth of that opinion as leave very little doubt in our minds. It must be confessed, however, that Mr Coxe reasons plausibly in support of the other opinion; and perhaps at this distance of time nothing can be said with certainty on this question, but what has been said by Johnson:

His fall was destined to a barren strand,
A petty fortress, and a dubious hand.
He left the name, at which the world grew pale,
To paint a moral, or adorn a tale.

Vanity of Human Wishes.

Sweden. exacted of him. The king, looking at him sternly, answered, "Think of what you are doing." "I do, replied Cederstrom; and what I think to-day, I shall think to-morrow: and were I capable of breaking the oath by which I am already bound to the states, I should be likewise capable of breaking that your majesty now requests me to take."

The king then ordered Cederstrom to deliver up his sword, and put him in arrest.

His majesty, however, apprehensive of the impression which the proper and resolute conduct of Cederstrom might make upon the minds of the other officers, shortly afterwards softened his tone of voice; and again addressing himself to Cederstrom, told him, that as a proof of the opinion he entertained of him, and the confidence he placed in him, he would return him his sword without insisting upon his taking the oath, and would only desire his attendance that day. Cederstrom continued firm; he answered, that his majesty could place no confidence in him that day, and that he begged to be excused from the service.

While the king was shut up with the officers, Senator Ralling, to whom the command of the troops in the town had been given two days before, came to the door of the guard room, and was told that he could not be admitted. The senator insisted upon being present at the distribution of the orders, and sent to the king to desire it; but was answered, he must go to the senate, where his majesty would speak to him.

The officers then received their orders from the king; the first of which was, that the two regiments of guards and of artillery should be immediately assembled, and that a detachment of 36 grenadiers should be posted at the door of the council-chamber to prevent any of the senators from coming out.

But before the orders could be carried into execution, it was necessary that the king should address himself to the soldiers; men wholly unacquainted with his designs, and accustomed to pay obedience only to the orders of the senate, whom they had been taught to hold in the highest reverence.

240
The king
gains over
the soldiers.

As his majesty, followed by the officers, was advancing from the guard room to the parade for this purpose, some of them more cautious, or perhaps more timid than the rest, became, on a short reflection, apprehensive of the consequences of the measure in which they were engaged: they began to express their fears to the king, that unless some persons of greater weight and influence than themselves were to take a part in the same cause, he could hardly hope to succeed in his enterprise. The king stopped a while, and appeared to hesitate. A serjeant of the guards overheard their discourse, and cried aloud,—"It shall succeed—Long live Gustavus!" His majesty immediately said, "Then I will venture;"—and stepping forward to the soldiers, he addressed them in terms nearly similar to those he had made use of to the officers, and with the same success. They answered him with loud acclamations: one voice only said, No; but it was not attended to.

In the mean time some of the king's emissaries had spread a report about the town that the king was arrested. This drew the populace to the palace in great numbers, where they arrived as his majesty had concluded his harangue to the guards. They testified by reiterated shouts their joy at seeing him safe; a joy which promised the happiest conclusion to the business of the day.

The senators were now immediately secured. They had from the window of the council-chamber beheld what was going forward on the parade before the palace; and, at a

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loss to know the meaning of the shouts they heard, were coming down to inquire into the cause of them, when 30 grenadiers, with their bayonets fixed, informed them it was his majesty's pleasure they should continue where they were. They began to talk in a high tone, but were answered only by having the door shut and locked upon them.

Sweden.
241
secures the
senators,
and be-
comes ma-
ster of the
whole

The moment the secret committee heard that the senate was arrested, they separated of themselves, each individual providing for his own safety. The king then mounting his horse, followed by his officers with their swords drawn, a large body of soldiers, and numbers of the populace, went to the other quarters of the town where the soldiers he had ordered to be assembled were posted. He found them all equally willing to support his cause, and to take an oath of fidelity to him. As he passed through the streets, he declared to the people, that he only meant to defend them, and save his country; and that if they would not confide in him, he would lay down his sceptre, and surrender up his kingdom. So much was the king beloved, that the people (some of whom even fell down upon their knees) with tears in their eyes implored his majesty not to abandon them.

The king proceeded in his course, and in less than an hour made himself master of all the military force in Stockholm. In the mean time the heralds, by proclamation in the several quarters of the city, summoned an assembly of the States for the ensuing morning, and declared all members traitors to their country who should not appear. Thither his majesty repaired in all the pomp of royalty, surrounded by his guards, and holding in his hand the silver sceptre of Gustavus Adolphus. In a very forcible speech, he lamented the unhappy state to which the country was reduced by the conduct of a party ready to sacrifice every thing to its ambition, and reproached the states with adapting their actions to the views of foreign courts, from which they received the wages of perfidy. "If any one dare contradict this, let him rise and speak."—Conviction, or fear, kept the assembly silent, and the secretary read the new form of government, which the king submitted to the approbation of the states. It consisted of fifty-seven articles; of which the following five were the chief.

1. The king has the entire power of convoking and dissolving the assembly of the states as often as he thinks proper. 2. His majesty alone has the command of the army, fleet, and finances, and the disposal of all offices civil and military. 3. In case of an invasion, or of any pressing necessity, the king may impose taxes, without waiting for the assembly of the states. 4. The diet can deliberate upon no other subjects than those proposed by the king. 5. The king shall not carry on an offensive war without the consent of the states. When all the articles were gone through, the king demanded if the states approved of them, and was answered by a general acclamation. He then dismissed all the senators from their employments, adding, that in a few days he would appoint others; and concluded this extraordinary scene by drawing out of his pocket a small book of psalms, from which, after taking off the crown, he gave out Te Deum. All the members very devoutly added their voices to his, and the hall resounded with thanksgivings, which it is to be feared never rose to heaven, if sincerity was necessary to their passport.

The power thus obtained the king employed for the good of his subjects. He took care that the law should be administered with impartiality to the richest noble and the poorest peasant, making a severe example of such judges as were proved to have made justice venal. He gave particular attention and encouragement to commerce, was a

242
Summons
an assembly
of the
states;

243
Which ac-
cepts a new
form of go-
vernment.

244
The king
makes a
good use of
his power.

Sweden. liberal and enlightened patron of learning and science, and laboured strenuously to introduce into his kingdom the most valuable improvements in agriculture that had been made in foreign countries.

245
Reforms
the army
and navy.

But while thus active in promoting the arts of peace, he was not inattentive to those of war. The fleet, which he found decayed and feeble, he in a few years restored to a respectable footing, and, besides changing the regulations of the navy, he raised a new corps of sailors, and formed them to the service by continual exercise. The army, which, as well as the navy, had been neglected during the aristocracy, was next to be reformed. The king began by giving cloaks, tents, and new arms to all the regiments. Afterwards, under the direction of Field Marshal Count de Hefsenstein, a new exercise was introduced, and several camps were formed, in which the soldiery were manœuvred by the king himself. The sale of military offices, which had been permitted for many years, was entirely suppressed; and the king provided not only for the re-establishment of discipline and good order in the army, but for the future welfare of the individuals which composed it. These warlike preparations were necessary to a plan which he had formed for entirely abolishing the power of the aristocracy, and freeing Sweden from the factions which had long been formed in it by the court of St Petersburg. The change which he had introduced into the constitution was very inimical to the intrigues of that court; and the Russian ambassador exerted himself openly to bring about a rupture between the king and the discontented nobles. Gustavus ordered him to quit the kingdom in eight days, and immediately prepared for war with Russia. To this apparently rash enterprise he was incited by the Ottoman Porte, at that time unable to oppose the armies of the two empires; and his own ambition, together with the internal state of his kingdom, powerfully concurred to make him lend every assistance to his ancient ally. It is needless for us to enter into a detail of the particulars of that war, which, as well as the astonishing activity and military skill displayed by the Swedish monarch, are fresh in the memory of all our readers. Suffice it to say, that neither Gustavus Adolphus nor Charles XII. gave greater proofs of undaunted courage and military conduct in their long and bloody wars than were given by Gustavus the III. from the end of the year 1787 to 1790, when peace was restored between the courts of St Petersburg and Stockholm. Had his army remained faithful, it seems in a high degree probable that he would have penetrated to the metropolis of the Russian empire in the first campaign; and when he was deserted by that army, and his councils distracted by new hostilities commenced against him by the Danes, the vigour and resources of his mind never forsook him. When the court of Copenhagen was compelled, by the means of England and Prussia, to withdraw its troops from the territories of Sweden, the king attacked Russia with such vigour both by sea and land, displayed such address in retrieving his affairs when apparently reduced to the last extremity, and renewed his attacks with such pertinacious courage, that the empress lowered the haughtiness of her tone, and was glad to treat with Gustavus as an equal and independent sovereign.

247
Not an arbitrary despot, tho' in some actions artificial and insidious.

The king of Sweden was now at liberty to cherish again the arts of peace, and to humble the haughty spirit of the nobles. For his attempting to deprive those men of that power which they had for many years employed against their country, he has been held up to the world as a despot who trampled on the liberties of his subjects; as a man without sincerity or patriotism; and, in one word, as a perjured tyrant, who overthrew the constitution which he had sworn to maintain. That he was not troubled with a scrupulous

conscience, when so artfully conducting the revolution of Sweden. 1772, must be acknowledged; nor can it be denied, that in his treaties with other powers he sometimes endeavoured to overreach them: but if the necessities of state could in any case be an apology for falsehood, they would sufficiently apologize for the duplicity of Gustavus. He was engaged in the arduous enterprise of freeing his subjects from an aristocratic tyranny supported by a foreign power the most formidable in the north; he had been forced into a war with that power, and, as there is reason to believe, promised assistance which he never received; and it cannot excite wonder nor great indignation, that, as soon as he could make an honourable peace, he embraced the opportunity without paying much regard to the interests of an alliance, which tamely looked on while he was struggling with difficulties apparently unsurmountable. That the revolution which he effected in his own country was calculated to promote the general good of the people, is unquestionable; and to gain such an object he might surely restore the crown to its ancient splendor, without bringing upon his government the odious epithet of *despotism*.

248
The revolution beneficial.

The nobles, however, continued discontented, and a conspiracy was planned against Gustavus under his own roof. He had entered into the alliance that was formed against the revolutionary government of France; and to raise an army which he was to lead in person to co-operate with the emperor and the king of Prussia, he was obliged to negotiate large loans, and to impose upon his subjects heavy taxes. The nobles took advantage of that circumstance to prejudice the minds of many of the people against the sovereign who had laboured so long for their real good. On the 16th of March 1792 he received an anonymous letter, warning him of his immediate danger from a plot that was laid to take away his life, requesting him to remain at home, and avoid balls for a year; and assuring him that, if he should go to the masquerade for which he was preparing, he would be assassinated that very night. The king read the note with contempt, and at a late hour entered the ball room. After some time he sat down in a box with the comte D'Essen, and observed that he was not deceived in his contempt for the letter, since had there been any design against his life, no time could be more favourable than that moment. He then mingled, without apprehension, among the crowd; and just as he was preparing to retire in company with the Prussian ambassador, he was surrounded by several persons in masks, one of whom fired a pistol at the back of the king, and lodged the contents in his body. A scene of dreadful confusion immediately ensued. The conspirators, amidst the general tumult and alarm, had time to retire to other parts of the room; but one of them had previously dropped his pistols and a dagger close by the wounded king. A general order was given to all the company to unmask, and the doors were immediately closed; but no person appeared with any particular distinguishing marks of guilt. The king was immediately conveyed to his apartment; and the surgeon, after extracting a ball and some slugs, gave favourable hopes of his majesty's recovery.

249
Produces a conspiracy against the king's life.

Suspensions immediately fell upon such of the nobles as had been notorious for their opposition to the measures of the court. The anonymous letter was traced up to colonel Liljehorn, major in the king's guards, and he was immediately apprehended. But the most successful clue that seemed to offer was in consequence of the weapons which had fallen from the assassin. An order was issued, directing all the armourers, gunsmiths, and cutlers in Stockholm, to give every information in their power to the officers of justice concerning the weapons. A gunsmith who had repaired the pistols readily recognized them to be the same which he

250
The king dangerously wounded.

Sweden. he had repaired some time since for a nobleman of the name of Ankarström, a captain in the army; and the cutler who had made the dagger referred at once to the same person.

251
The king dies.

The king languished from the 17th to the 29th of March. At first the reports of his medical attendants were favourable; but on the 28th a mortification was found to have taken place, which terminated his existence in a few hours. On opening his body, a square piece of lead and two rusty nails were found unextracted within the ribs.

252
His behaviour before his death.

During his illness, and particularly after he was made acquainted with the certainty of his approaching dissolution, Gustavus continued to display that unshaken courage which he had manifested on every occasion during his life. A few hours before his decease he made some alterations in the arrangement of public affairs. He had before, by his will, appointed a council of regency; but convinced, by recent experience, how little he could depend on the attachment of his nobles, and being also aware of the necessity of a strong government in difficult times, he appointed his brother, the duke of Sudermania, sole regent, till his son, who was then about fourteen, shall have attained the age of eighteen years. His last words were a declaration of pardon to the conspirators against his life. The actual murderer alone was excepted; and he was excepted only at the strong instance of the regent, and those who surrounded his majesty in his dying moments. Immediately on the death of the king, the young prince was proclaimed by the title of Gustavus IV.

253
Punishment of the conspirators.

Ankarström was no sooner apprehended, than he confessed with an air of triumph, that he was the person "who had endeavoured to liberate his country from a monster and a tyrant." Suspicions at the same time fell on the counts Horn and Ribbing, baron Pechlin, baron Ehrensvard, baron Hartsmändorf, Von Engerström the royal secretary, and others; and these suspicions were confirmed by the confession of Ankarström. After a very fair and ample trial, this man was condemned to be publicly and severely whipped on three successive days, his right hand and his head to be cut off, and his body impaled; which sentence he suffered not till the 17th of May, long after the death of the king. —His property was given to his children, who, however, were compelled to change their name.

The counts Horn and Ribbing were condemned to lose their right hands, and to be decapitated. Col. Liljehorn and lieutenant Ehrenjwärd were also to be beheaded. —All these conspirators were degraded from the rank of nobles, and their property declared to be confiscated. Major Hartsmändorf was to forfeit his rank in the army, and to be imprisoned for one year. Engerström was to suffer perpetual imprisonment, and baron Pechlin and secretary Lilleström to be imprisoned during pleasure. Four others, accused of being concerned in the conspiracy, were pardoned, and some were acquitted.

254
Division of Sweden.

The kingdom of Sweden, in its present state, is divided into the following provinces: 1. Sweden Proper. 2. Gothland. 3. Finland. 4. Swedish Lapland. And, 5. The Swedish islands. Great abatements must be made for the lakes and unimproved parts of Sweden, which are so extensive that the habitable part is confined to narrow bounds.

255
Climate, soil, &c.

The face of Sweden is pretty similar to those of its neighbouring countries; only it has the advantage of navigable rivers.

The same may be said with regard to its climate, soil, &c. Summer bursts from winter; and vegetation is more speedy than in southern climates. Stoves and warm furs mitigate the cold of winter, which is so intense, that the noses and extremities of the inhabitants are sometimes mortified. The Swedes, since the days of Charles XII. have

Sweden. been at incredible pains to correct the native barrenness of their country, by erecting colleges of agriculture, and in some places with great success. The soil is much the same with that of Denmark and some parts of Norway, generally very bad, but in some valleys surprisingly fertile. The Swedes, till of late years, had not industry sufficient to remedy the one, nor improve the other. The peasants now follow the agriculture of France and England; and some late accounts say, that they rear almost as much grain as maintains the natives. Gothland produces wheat, rye, barley, oats, pease, and beans; and in case of deficiency, the people are supplied from Livonia and the Baltic provinces. In summer, the fields are verdant, and covered with flowers; and produce strawberries, raspberries, currants, and other small fruits. The common people know, as yet, little of the cultivation of apricots, peaches, nectarines, pine-apples, and the like high-flavoured fruits; but melons are brought to great perfection in dry seasons.

Sweden produces crystals, amethysts, topazes, porphyry, lapis lazuli, agate, cornelian, marble, and other fossils. The chief wealth of the country, however, arises from her mines of silver, copper, lead, and iron. The last-mentioned metal employs no fewer than 450 forges, hammering-mills, and smelting-houses. A kind of a gold mine has likewise been discovered in Sweden; but so inconsiderable, that from the year 1741 to 1747, it produced only 2398 gold ducats, each valued at 9s. 4d. sterling. The first gallery of one silver mine is 100 fathoms below the surface of the earth; the roof is supported by prodigious oaken beams, and from thence the miners descend about 40 fathoms to the lowest vein. This mine is said to produce 20,000 crowns a-year. The product of the copper mines is uncertain; but the whole is loaded with vast taxes and reductions to the government, which has no other resources for the exigences of state. Those subterraneous mansions are astonishingly spacious, and at the same time commodious for their inhabitants, so that they seem to form a hidden world. The water-falls in Sweden afford excellent convenience for turning mills for forges; and for some years the exports of iron from Sweden brought in 300,000l. sterling. Dr Busching thinks that they constituted two-thirds of the national revenue. It must, however, be observed, that the extortions of the Swedish government, and the importation of American bar-iron into Europe, and some other causes, have greatly diminished this manufacture in Sweden; so that the Swedes very soon must apply themselves to other branches of trade and improvements, especially in agriculture.

256

The animals differ little from those of Norway and Denmark, only the Swedish horse are known to be more serviceable in war than the German. The fishes found in the rivers and lakes of Sweden are the same with those in other northern countries, and taken in such quantities, that their pikes (particularly) are salted and pickled for exportation. The train-oil of the seals, taken in the gulph of Finland, is a considerable article of exportation.

257

There is a great diversity of characters among the people of Sweden; and what is peculiarly remarkable among them, they have been known to have different characters in different ages. At present, their peasants seem to be a heavy plodding race of men, strong and hardy; but without any other ambition than that of subsisting themselves and their families as well as they can; they are honest, simple, and hospitable; and the mercantile classes are much of the same cast; but great application and perseverance is discovered among them all. One could form no idea that the modern Swedes are the descendants of those who, under Gustavus Adolphus and Charles XII. carried terror in their

Sweden. names through the most distant countries, and shook the foundations of the greatest empires. The principal nobility and gentry of Sweden are naturally brave, polite, and hospitable; they have high and warm notions of honour, and are jealous of their national interests. The dress of the common people is almost the same with that of Denmark: the better sort are infatuated with French modes and fashion. The common diversions of the Swedes are, skating, running races in sledges, and sailing in yachts upon the ice. They are not fond of marrying their daughters when young, as they have little to spare in their own life-time. The women go to plough, thresh out the corn, row upon the water, serve the brick layers, carry burdens, and do all the common drudgeries in husbandry.

258
Religion.

Christianity was introduced here in the 9th century. Their religion is Lutheran, which was propagated among them by Gustavus Vasa, about the year 1523, as we have already related. The Swedes are surprisingly uniform and unremitting in religious matters; and have such an aversion to Popery, that castration is the fate of every Roman Catholic priest discovered in their country. The archbishop of Upsal has a revenue of about 400l. a-year; and has under him thirteen suffragans, besides superintendants, with moderate stipends. No clergyman has the least direction in the affairs of state; but their morals, and the sanctity of their lives, endear them so much to the people, that the government would repeat making them its enemies. Their churches are neat, and often ornamented. A body of ecclesiastical laws and canons direct their religious economy. A conversion to Popery, or a long continuance under excommunication, which cannot pass without the king's permission, is punished by imprisonment and exile.

259
Language.

The Swedish language is a dialect of the Teutonic, and resembles that of Denmark. The Swedish nobility and gentry are, in general, more conversant in polite literature than those of many other more flourishing states. They have of late exhibited some noble specimens of their munificence for the improvement of literature and science, particularly natural history.

260
Manufactures, &c.

The Swedish commonalty subsists by agriculture, mining, grazing, hunting, and fishing. Their materials for traffic are the bulky and useful commodities of masts, beams, and other sorts of timber for shipping; tar, pitch, bark of trees, potash, wooden utensils, hides, flax, hemp, peltry, furs, copper, lead, iron, cordage, and fish.

Even the manufacturing of iron was introduced into Sweden so late as the 16th century; for till that time they sold their own crude ore to the Hanse-towns, and bought it back again manufactured into utensils. About the middle of the 17th century, by the assistance of the Dutch and Flemings, they set up some manufactures of glass, starch, tin, woollen, silk, soap, leather-dressing, and saw-mills. Bookselling was at that time a trade unknown in Sweden. They have since had sugar-baking, tobacco-plantations, and manufactures of sail-cloth, cotton, fustian, and other stuffs; also of linen, alum, brimstone, paper-mills, and gunpowder-mills. Vast quantities of copper, brass, steel, and iron, are now wrought in Sweden, dug from mines, some of them more than 1100 feet deep. The iron mine of Dannemora, which is much the most profitable of any of those with which every part of Sweden abounds, is said to yield 60lb. of metal in a 100lb. of ore, and the others about 30lb. The iron extracted from this is known in Europe under the name of *Oregrund*; which name is derived from a sea-port on the Baltic. A large portion of it is employed by different nations for making the best steel. The mine was discovered in 1470. The unwrought ore was first sold to the merchants of Lubeck. It was not until the reign of Gustavus

Vasa that the Swedes worked it themselves. It is asserted, **Sweden.** that the mine of Dannemora yields about 40,000 stones of bar-iron per year, which is supposed to be one tenth part of the quantity which all the iron-mines of Sweden produce. Of this product, amounting to 400,000 stones, 300,000 are annually exported; the remainder is manufactured at home. It is calculated that no less than 25,600 men are employed in mining, and the branches immediately connected with it, viz. 4000 for breaking the rocks, either by explosion or manual labour; 10,800 to hew timber and burn it into charcoal; 2000 are employed in smelting; 1800 in transporting the metal from the furnaces to the forges; 600 in transporting sand, fuel, &c. 4000 for transporting the charcoal, and 2400 at the forges. They have also founderies for cannon, forgeries for fire-arms and anchors, armories, wire and flattening-mills, mills also for fulling, and for boring and stamping: and of late they have built many ships for sale.

There are likewise in Sweden some silver mines, of which that of *Salha*, or *Salberg*, is the richest as well as the most ancient. It existed so early as 1188, and, during the whole of the 14th century, it yielded 24,000 marks of silver per annum. In the 15th century the quantity was diminished to 20,000. In the reign of Charles X. it gave only 2000, and it furnishes at present still less, the ore yielding only one ounce of pure metal per quintal. The chief gallery where the purest silver was obtained having fallen in, is not yet cleared, notwithstanding their incessant labour. They are also digging pits in a perpendicular direction, in order to arrive at the principal vein, which extends itself from the north to the south-east. Formerly lead employed in separating the metal was imported from England; but the mine furnishes at present a sufficient quantity for the purpose.

Certain towns in Sweden, being 24 in number, are called *Staple-towns*, where the merchants are allowed to import and export commodities in their own ships. Those towns which have no foreign commerce, though lying near the sea, are called *land-towns*. A third kind are termed *mine-towns*, as belonging to mine-districts. The Swedes, about the year 1752, had greatly increased their exports, and diminished their imports, most part of which arrive or are sent off in Swedish ships; the Swedes having now a kind of navigation act like that of the English. Those promising appearances were, however, blasted by the madness and jealousies of the Swedish government; and the people so oppressed with taxes, that some important revolution was daily expected in that kingdom.

The revenue of Sweden, since the unfortunate wars of **261** **Revenues.** Charles XII. has been greatly reduced. Her gold and silver species, in the reign of Ad. Frederic, arose chiefly from the king's German dominions. Formerly, the crown-lands, poll-money, tithes, mines, and other articles, are said to have produced a million sterling. The payments that are made in copper, which is here the chief medium of commerce, is extremely inconvenient; some of those pieces being as large as tiles; and a cart or wheelbarrow is often required to carry home a moderate sum. The Swedes, however, have gold ducats, and eight-mark pieces of silver, valued each at 5s. 2d. and the subsidies paid them by France help to increase their currency.

No country in the world has produced greater heroes or **262** **Military** braver troops than the Swedes; and yet they cannot be **Strength.** said to maintain a standing army, as their forces consist of a regulated militia. The cavalry is clothed, armed, and maintained, by a rate raised upon the nobility and gentry, according to their estates; and the infantry by the peasants. Each province is obliged to find its proportion of soldiers, according

Sweden- according to the number of farms it contains; every farm
borg. of 60l. or 70l. *per annum* is charged with a foot-soldier,
furnishing him with diet, lodging, and ordinary clothes,
and about 20s. a-year in money; or else a little wooden
house is built him by the farmer, who allows him hay
and pasturage for a cow, and ploughs and sows land
enough to supply him with bread. When embodied,
they are subject to military law, but otherwise to the civil
law of the country. It may therefore literally be said,
that every Swedish soldier has a property in the coun-
try he defends. This national army is thought to amount
to above 50,000 men. Sweden formerly could have fit-
ted out 40 ships of the line.

SWEDENBORG (Emanuel), was born at Stockholm
on the 29th of January 1689. His father was bishop of
West-Gothia; member of a society for the propagation of
the gospel, formed on the plan of that of England; and
president of the Swedish church in Pennsylvania and Lon-
don. To this last office he was appointed by Charles XII.
who seems to have had a great regard for the bishop, and
to have continued that regard to his son.

Of the course of young Swedenborg's education we have
procured no account; but from the character of the father,
it may be supposed to have been pious; and by his appear-
ing with reputation as an author, when but 20 years of age,
it is proved to have been successful. His first work was
published in 1709; and the year following he sent into the
world a collection of pieces on different subjects, in Latin
verse, under the title of *Ludus Heliconius, sive Carmina Mis-
cellanea quæ variis in locis cecinit*. The same year he began
his travels, first into England, and afterwards into Holland,
France, and Germany; and returning to Stockholm in
1714, he was two years afterwards appointed to the of-
fice of assessor in the Metallic College by Charles XII. who
honoured him with frequent conversations, and bestowed up-
on him a large share of his favour. At this period of his
life Swedenborg devoted his attention principally to physic
and mathematical studies; and in 1718 he accompanied the
king to the siege of Frederickshall, where he gave an eminent
proof that he had not studied in vain. Charles could not
send his heavy artillery to Frederickshall from the bad-
ness of the roads, which were then rendered much worse
than usual by being deeply covered with snow. In this
extremity Swedenborg brought the sciences to the aid of
valour. By the help of proper instruments he cut through
the mountains, and raised the valleys which separated Swe-
den from Norway, and then sent to his master two galleys,
five large boats, and a sloop, loaded with battering pieces;
to be employed in the siege. The length of this canal was
about two miles and a half. The execution of this great
work, however, did not occupy all his time. In 1716 he
had begun to publish essays and observations on the mathema-
tical and physical sciences, under the title of *Dædalus Hyper-
boreus*; and he found leisure during the siege to complete his
intended collection, and also in the same year to publish
an introduction to algebra, under the whimsical title of *The
Art of the Rules*.

At the siege of Frederickshall he lost his patron Charles;
but found another in Ulrica Eleonora, the sister and succes-
sor of that hero, by whom in 1719 he was ennobled, and
took of course his seat among the senators of the equestrian
order in the triennial assemblies of the states. His promo-
tion did not lessen his ardour for the sciences; for he pub-
lished in the same year *A Method to fix the Value of Money,
and to determine the Swedish Measures in such a way as to sup-
press all the Fractions and facilitate the Calculations*. About
the same time he gave the public a treatise on the Position

and Course of the Planets; with another on the Height of the
Tides, and Flux and Reflux of the Sea; which, from infor-
mation gathered in different parts of Sweden, appeared to
have been greater formerly than when he wrote.

As Swedenborg continued, under the new sovereign, to
hold the office of assessor to the Metallic College, he thought
it necessary, for the discharge of his duty, to make a second
journey into foreign countries, that he might himself exa-
mine their mines, particularly those of Saxony and Harts.
During these travels, which were undertaken for the im-
provement of the manufactures of his native country, he
printed at Amsterdam, 1. *Prodromus principiorum Naturali-
um, sive novorum tentaminum, Chemicam et Physicam experimen-
talem geometricè explicandi*. 2. *Nova observata & inventa cir-
ca Ferrum & Ignem, præcipue naturam Ignis Elementarum, una
cum nova Camini inventione*. 3. *Methodus nova inveniendi
Longitudines locorum terræ marique ope Lunæ*. 4. *Modus
construendi receptacula navalia, vulgo en Susdois, Dockbyhna-
der*. 5. *Nova constructio aggeris aquatici*. 6. *Modus explo-
randi virtutes Navigiorum*. And at Leipzig and Hamburg,
7. *Miscellanea observata circa res naturales, præsertim Mine-
ralia, Ignem, & Montium strata*.

This journey was made, and these tracts published, in the
compass of a year and a half; and perhaps there has not
been another man, Linnæus excepted, who has done so much
in so short a time. After his return in 1722, Swedenborg
divided his time so equally between the duties of his office
and his private studies, that in 1733 he finished his grand
work, entitled *Opera Philosophica & Mineralia*, and had it
printed under his own direction in 1734, part at Dresden
and part at Leipzig; in which year he also went to inspect
the mines of Austria and Hungary. This work is divided
into three volumes folio; the title of the first is *Principia
rerum Naturalium sive novorum tentaminum, Phenomena Mun-
di elementaris philosophicè explicandi*. The second, *Regnum
subterraneum sive Minerale de Ferro*; and the third, *Regnum
subterraneum sive Minerale de Cupro, & Orichalco*; all of
them written with great strength of judgment, and orna-
mented with plates, to facilitate the comprehension of the
text.

In the year 1729 he was enrolled among the members of
the Society of Sciences at Upsal, and was, probably about the
same time, made a Fellow of the Royal Academy of Sci-
ences at Stockholm; nor were strangers less willing than his
own countrymen to acknowledge the greatness of his me-
rit. Wolfius, with many other learned foreigners, were ea-
ger to court his correspondence. The Academy of St Pe-
tersburg sent him, on the 17th of December 1734, a di-
ploma of association as a correspondent member; and soon
afterwards the editors of the *Acta Eruditorum* at Leipzig
found in his works a valuable supplement to their own col-
lection.

By many persons the approbation of learned academies
would have been highly valued; but by Baron Swedenborg
it was considered as of very little importance. "Whatever
of wordly honour and advantage may appear to be in the
things before mentioned, I hold them (says he) but as mat-
ters of low estimation, when compared to the honour of that
holy office to which the Lord himself hath called me, who
was graciously pleased to manifest himself to me, his un-
worthy servant, in a personal appearance, in the year 1743,
to open in me a sight of the spiritual world, and to enable
me to converse with spirits and angels; and this privilege
has continued with me to this day. From that time I be-
gan to print and publish various unknown Arcana, which
have been either seen by me or revealed to me, concerning
heaven and hell, the state of men after death, the true wor-
ship

Sweden-
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European
Magazine,
1787, July.

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ship of God, the spiritual sense of the Scriptures, and many other important truths tending to salvation and true wisdom."

We shall not affront the understandings of our readers by making upon this account of the Baron's *call* such reflections as every person of a sound mind will make for himself; but it is rather remarkable, that a man who had devoted the better part of his life to the study of such sciences as generally fortify the mind against the delusions of fanaticism, and who had even excelled in these sciences, should have fallen into such a reverie as this. After this extraordinary call, the Baron dedicated himself wholly to the great work which, he supposed, was assigned him, studying diligently the word of God, and from time to time publishing to his fellow-creatures such important information as was made known to him concerning another world. Among his various discoveries concerning the spiritual world, one is, that it exists not in space. "Of this (says he) I was convinced, because I could there see Africans and Indians very near me, although they are so many miles distant here on earth; nay, that I could be made present with the inhabitants of other planets in our system, and also with the inhabitants of planets that are in other worlds, and revolve about other suns. By virtue of such presence (*i. e.* without real space), not of place, I have conversed with apostles, departed popes, emperors, and kings; with the late reformers of the church, Luther, Calvin, and Melancthon, and with others from distant countries."

Notwithstanding the want of space in the spiritual world, he tells us, "that after death a man is so little changed that he even does not know but he is living in the present world; that he eats and drinks, and even enjoys conjugal delight as in this world; that the resemblance between the two worlds is so great, that in the spiritual world there are cities, with palaces and houses, and also writings and books, employments and merchandizes; that there is gold, silver, and precious stones there. In a word (he says), there is in the spiritual world all and every thing that there is in the natural world, but that in heaven such things are in an infinitely more perfect state."

Such was his zeal in the propagation of these whimsical and sometimes sensual doctrines, that he frequently left his native country to visit distant cities, particularly London and Amsterdam, where all his theological works were printed at a great expence, and with little prospect or probability of a reimbursement. "Wherever he resided when on his travels, he was (says one of his admirers) a mere solitary, and almost inaccessible, though in his own country of a free and open behaviour. He affected no honour, but declined it; pursued no worldly interest, but spent his time in travelling and printing, in order to communicate instruction and benefit to mankind. He had nothing of the precise in his manner, nothing of melancholy in his temper, and nothing in the least bordering on enthusiasm in his conversation or writings." This is too much. We believe he was an inoffensive visionary; of his conversation we cannot judge; but the specimens that we have given of his writings are frantic enthusiasm. He died at London, March 29th, in the year 1772; and after lying in state, his remains were deposited in a vault at the Swedish church, near Radcliff-Highway.

Though Baron Swedenborg's followers appear not to have been numerous during his life, they have increased since his death; and a sect subsists at present in England which derives its origin from him, and is called *the New Jerusalem Church*. The discriminating tenets of this sect seem to be the following: "Holding the doctrine of one God, they maintain that this one God is no other than Je-

sus Christ, and that he always existed in a human form; that for the sake of redeeming the world; he took upon himself a proper human or material body, but not a human soul; that this redemption consists in bringing the hells or evil spirits into subjection, and the heavens into order and regulation, and thereby preparing the way for a new spiritual church; that without such redemption no man could be saved, nor could the angels retain their state of integrity; that their redemption was effected by means of trials, temptations, or conflicts with evil spirits; and that the last of them, by which Christ glorified his humanity, perfecting the union of his divine with his human nature, was the passion of the cross. Though they maintain that there is but one God, and one divine person, they hold that in this person there is a real Trinity; consisting of the divinity, the humanity, and the operation of them both in the Lord Jesus; a Trinity which did not exist from all eternity, but commenced at the incarnation. They believe that the Scriptures are to be interpreted not only in a literal but in a spiritual sense, not known to the world till it was revealed to B. Swedenborg; and that this spiritual sense extends to every part of Scripture, except the Acts of the Apostles. They believe that there are angels attending upon men, residing, as B. Swedenborg says, in their affections; that temptation consists in a struggle between good and bad angels within men; and that by this means God assists men in these temptations, since of themselves they could do nothing. Indeed B. Swedenborg maintains, that there is an universal influx from God into the souls of men, inspiring them especially with the belief of the divine unity. This efflux of divine light on the spiritual world he compares to the efflux of the light from the sun in the natural world.

"There are (says B. Swedenborg) two worlds, the natural and the spiritual, entirely distinct, though perfectly corresponding to each other; that at death a man enters into the spiritual world, when his soul is clothed with a body, which he terms *substantial*, in opposition to the present *material* body, which, he says, is never to rise out of the grave."

SWEEP, in the sea-language, is that part of the mould of a ship where she begins to compass in the rung-heads. also when the hauser is dragged along the bottom of the sea to recover any thing that is sunk, they call this action *sweeping for it*.

SWEET, in the wine trade, denotes any vegetable juice, whether obtained by means of sugar, raisins, or other foreign or domestic fruit, which is added to wines with a design to improve them.

SWEIN-MOT. See *FOREST Courts*.

SWERTIA, **MARSH GENTIAN**, in botany: A genus of plants belonging to the class of *pentandria*, and to the order of *digynia*; and in the natural system ranging under the 20th order, *rotaceæ*. The corolla is wheel-shaped. There are nectariferous pores at the bases of the segments of the corolla. The capsule is unilocular and bivalve. There are six species; the *perennis*, *difformis*, *rotata*, *carinthiaca*, *corniculata*, *dichotoma*. The *perennis* is a native of England. It is distinguished by radical oval leaves. It flowers in August.

SWIETENIA, **MAHOGANY**, in botany: A genus of plants belonging to the class of *decandria*, and to the order of *monogynia*; and in the natural system arranged under the 54th order, *Miscellaneæ*. The calyx is quinquefid. There are five petals; the nectarium is cylindrical, supporting the antheræ with its mouth. The capsule is five-celled, woody, and opening at the mouth. The seeds are imbricated and winged. There is only one species, the mahagoni, which is a native of the warmest parts of America, and grows also

Sweden-
borg
||
SwieteniaPriestley's
Letters to
the New
Jerusalem
Church,
p. 4. &c.Sweden-
borg's Uni-
versal Theo-
logy, vol. i.
p. 87.Ibid.
Nº 734.Short Ac-
count, &c.
p. 11
and Har-
ley's Pre-
face to the
Treatise on
Influx.

Swietenia, in the island of Cuba, Jamaica, Hispaniola, and the Bahama islands. It abounded formerly in the low lands of Jamaica, but it is now found only on high hills and places difficult of access.

London Medical Journal.

Brown's Natural History of Jamaica.

It thrives in moist soils, but varies in texture and grain according to the nature of the soil. On rocks it is of a smaller size, but very hard and weighty, of a close grain, and beautifully shaded; while the produce of the low and richer lands is observed to be more light and porous, of a paler colour and open grain; and that of mixed soils to hold a medium between both. The tree grows very tall and straight, and is usually four feet in diameter; the flowers are of a reddish or saffron colour, and the fruit of an oval form, and about the size of a turkey's egg.

The wood is generally hard, takes a fine polish, and is found to answer better than any other sort in all kinds of cabinet ware. It is now universally esteemed, and sells at a good price; but it is pity that it is not cultivated in the more convenient waste lands of Jamaica. It is a very strong timber, and answers very well in beams, joists, plank, boards, and shingles; and has been frequently put to those uses in Jamaica in former times. It is said to be used sometimes in ship-building; a purpose for which it is remarkably adapted, if not too costly, being very durable, capable of resisting gun-shots, and burying the shots without splintering.

Philosophical Transactions, No 484.

The seed-vessels are of a curious form, consisting of a large cone splitting into five parts, and disclosing its winged seeds, disposed in the regular manner of those of an apocynum. The seeds being winged, are dispersed on the surface of the ground, where some falling into the chinks of the rocks, strike root; then creep out on the surface of it, and seek another chink, into which they creep and swell to such a size and strength, that at length the rock splits, and is forced to admit of the root's deeper penetration; and with this little nutriment the tree increases to a stupendous size in a few years.

The first use to which mahogany was applied in England, was to make a box for holding candles. Dr Gibbons, an eminent physician in the latter end of the last and beginning of the present century, had a brother, a West India captain, who brought over some planks of this wood as ballast. As the Doctor was then building him a house in King-street, Covent-Garden, his brother thought they might be of service to him. But the carpenters, finding the wood too hard for their tools, they were laid aside for a time as useless. Soon after, Mrs Gibbons wanting a candle-box, the Doctor called on his cabinet-maker (Wollaston in Long-Acre) to make him one of some wood that lay in his garden. Wollaston also complained that it was too hard. The Doctor said he must get stronger tools. The candle-box was made and approved; inasmuch, that the Doctor then insisted on having a bureau made of the same wood, which was accordingly done; and the fine colour, polish, &c. were so pleasing, that he invited all his friends to come and see it. Among them was the duchess of Buckingham. Her Grace begged some of the same wood of Dr Gibbons, and employed Wollaston to make her a bureau also; on which the fame of mahogany and Mr Wollaston was much raised, and things of this sort became general. This account was given by Henry Mill, Esq; a gentleman of undoubted veracity.

SWIFT (Dr Jonathan), so universally admired as a wit and classical writer of the English language, was born in Dublin on November 30th 1667. His father was an attorney, and of a good family; but dying poor, the expence of his son's education was defrayed by his friends. At the age of six young Swift was sent to the school of Kilkenny,

whence he was removed in his 15th year to Trinity College, Dublin.

Swift.

In his academical studies (says Dr Johnson) he was either not diligent or not happy. The truth appears to be, that he despised them as intricate and useless. He told Mr Sheridan, his last biographer, that he had made many efforts, upon his entering the college, to read some of the old treatises on logic written by Smeglesius, Keckermannus, Burgerfidius, &c. and that he never had patience to go thro' three pages of any of them, he was so disgusted at the stupidity of the work. When he was urged by his tutor to make himself master of this branch, then in high estimation, and held essentially necessary to the taking of a degree, Swift asked him, What it was he was to learn from those books? His tutor told him, The art of reasoning. Swift said, That he found no want of any such art; that he could reason very well without it; and that, as far as he could observe, they who had made the greatest proficiency in logic had, instead of the art of reasoning, acquired the art of wrangling; and instead of clearing up obscurities, had learned how to perplex matters that were clear enough before. For his own part, he was contented with that portion of reason which God had given him; and he would leave it to time and experience to strengthen and direct it properly; nor would he run the risk of having it warped or falsely biased by any system of rules laid down by such stupid writers, of the bad effects of which he had but too many examples before his eyes in those reckoned the most acute logicians. Accordingly, he made a firm resolution, that he never would read any of those books; which he so pertinaciously adhered to, that though his degree was refused him the first time of sitting for it, on account of his not answering in that branch, he went into the hall a second time as ill prepared as before; and would also have been stopped a second time, on the same account, if the interest of his friends, who well knew the inflexibility of his temper, had not stepped in, and obtained it for him; though in a manner little to his credit, as it was inserted in the College Registry, that he obtained it *speciali gratia*, "by special favour;" where it remains upon record.

"He remained in the college near three years after this, not through choice, but necessity, little known or regarded. By scholars he was reckoned a blockhead; and as the lowliness of his circumstances would not permit him to keep company with persons of an equal rank with himself, upon an equal footing, he scorned to take up with those of a lower class, or to be obliged to those of a higher. He lived therefore much alone, and his time was employed in pursuing his course of reading in history and poetry, then very unfashionable studies for an academic; or in gloomy meditations on his unhappy circumstances. Yet, under this heavy pressure, the force of his genius broke out, in the first rude draught of the Tale of a Tub, written by him at the age of 19, though communicated to nobody but his chamber-fellow Mr Waryng; who, after the publication of the book, made no scruple to declare, that he had read the first sketch of it in Swift's hand-writing when he was of that age."

In 1688, being, by the death of Godwin Swift his uncle, who had chiefly supported him, left without subsistence, he went to consult his mother, who then lived at Leicester, about the future course of his life; and, by her direction, solicited the advice and patronage of Sir William Temple, whose father had lived in great friendship with Godwin Swift. Temple received him with great kindness, and was so much pleased with his conversation, that he detained him two years in his house, and recommended him to king William, who offered to make him a captain of horse. This not suiting his disposition, and Temple not having it quickly

Swift. in his power to provide for him otherwise, Swift left his patron (1694) in discontent; having previously taken his master's degree at Oxford, by means of a testimonial from Dublin, in which the words of disgrace were omitted. He was resolved to enter into the church, where his first preferment was only L. 100 a-year, being the prebend of *Kilroot* in *Conner*; which some time afterwards, upon Sir William Temple's earnestly inviting him back to his house at Moorpark, he resigned in favour of a clergyman far advanced in years and burdened with a numerous family. For this man he solicited the prebend, to which he himself inducted him.

In 1699 Swift lost his patron Sir William Temple, who left him a legacy in money, with the property of his manuscripts; and, on his death-bed, obtained for him a promise from the king of the first prebend that should become vacant at Westminster or Canterbury. That this promise might not be forgotten, Swift dedicated to the king the posthumous works with which he was entrusted, and for a while attended the court; but soon found his solicitations hopeless. He was then invited by the earl of Berkeley to accompany him into Ireland, where, after suffering some cruel disappointments, he obtained the livings of Laracor and Rathbeggin in the diocese of Meath; and soon afterwards invited over the unfortunate Stella, a young woman of the name of Johnson, whose life he contrived to embitter, and whose days, though he certainly loved her, we may confidently affirm that he shortened by his caprice.

This lady is generally believed to have been the daughter of Sir William Temple's steward; but her niece, a Mrs Hearn, assured Mr Berkeley, the editor of a volume of letters intitled *Literary Relics*, that her father was a merchant, and the youngest brother of a good family in Nottinghamshire; that her mother was the intimate friend of lady Gifford, Sir William's sister; and that she herself was educated in the family with his niece, the late Mrs Temple of Moorpark by Farnham*. This story would be intitled to the fullest credit, had not Mrs Hearn affirmed, in the same letter, that, before the death of Sir William Temple, Mrs Johnson's little fortune had been greatly injured by the South-Sea bubbles, which are known to have injured no person till the year 1720: (See COMPANY, II. 1.) When one part of a narrative is so palpably false, the remainder will always be received with hesitation. But whether Miss Johnson was the daughter of Temple's steward or of the friend of lady Gifford, it is certain that Sir William left her L. 1000; and that, accompanied by Mrs Dingley, whose whole fortune amounted to an annuity of L. 27 for life, she went, in consequence of Swift's invitation, to Laracor. With these two ladies he passed his hours of relaxation, and to them he opened his bosom; but they never resided in the same house, nor did he see either without a witness.

In 1701 Swift published *A discourse of the contests and dissensions in Athens and Rome*. It was his first work, and indeed the only which he ever expressly acknowledged. According to his constant practice he had concealed his name; but after its appearance, paying a visit to some Irish bishop, he was asked by him if he had read that pamphlet, and what its reputation was in London. Upon his replying that he believed it was very well liked in London; "Very well liked!" said the bishop with some emotion. "Yes, Sir, it is one of the finest tracts that ever was written, and bishop Burnet is one of the best writers in the world." Swift, who always hated Burnet with something more than political rancour, immediately questioned his right to the work, when he was told by the bishop that he was "a young man;" and still persisting to doubt of the justice of Burnet's claim, on account of the dissimilarity of the style of the

pamphlet from that of his other works, he was told that he was "a very positive young man," as no person in England but bishop Burnet was capable of writing it. Upon which Swift replied, with some indignation, I am to assure your lordship, however, that bishop Burnet did *not* write the pamphlet, for I wrote it myself. And thus was he forced in the heat of argument to avow what otherwise he would have for ever concealed.

Early in the ensuing spring king William died; and Swift, on his next visit to London, found queen Anne upon the throne. It was generally thought, upon this event, that the Tory party would have had the ascendant; but, contrary to all expectation, the Whigs had managed matters so well as to get entirely into the queen's confidence, and to have the whole administration of affairs in their hands. Swift's friends were now in power; and the Whigs in general, knowing him to be the author of the *Discourse on the Contests*, &c. which was written in defence of king William and his ministers against the violent proceedings of the house of commons, considered themselves as much obliged to him, and looked upon him as fast to their party. But Swift thought with the Whigs only in the state; for with respect to the church his principles were always those of a Tory. He therefore declined any intimate connection with the leaders of the party, who at that time professed what was called *low church principles*. But what above all shocked him, says Mr Sheridan, was their inviting Deists, Freethinkers, Atheists, Jews, and Infidels, to be of their party, under pretence of moderation, and allowing a general liberty of conscience. As Swift was in his heart a man of true religion, he could not have borne, even in his private character, to have mixed with such a motley crew. But when we consider his principles in his political capacity, that he looked upon the church of England, as by law established, to be the main pillar of our newly erected constitution, he could not, consistently with the character of a good citizen, join with those who considered it more as an ornament than a support to the edifice; and could therefore look on with composure while it was undermining, or could even open the gate to a blind multitude, to try, like Sampson, their strength against it, and consider it only as sport. With such a party, neither his religious nor political principles would suffer him to join; and with regard to the Tories, as is usual in the violence of factions, they had run into opposite extremes, equally dangerous to the state. He was therefore during the earlier part of the queen's reign of no party, but employed himself in discharging the duties of his function, and in publishing from time to time such tracts as he thought might be useful. In the year 1704 he published the *Tale of a Tub*, which, considered merely as a work of genius, is unquestionably the greatest which he ever produced; but the levity with which religion was thought to be there treated, raised up enemies to him among all parties, and eventually precluded him from a bishopric. From that period till the year 1708, he seems to have employed himself in solitary study; but he then gave successively to the public *The Sentiments of a Church of England man*, the ridicule of astrology under the name of *Bickerstaff*, the *Argument against abolishing Christianity*, and the defence of the *Sacramental Test*.

Soon after began the busy and important part of Swift's life. He was employed (1710) by the primate of Ireland to solicit the queen for a remission of the first fruits and twentieth parts to the Irish clergy. This introduced him to Mr Harley, afterwards earl of Oxford, who, though a Whig himself, was at the head of the Tory ministry, and in great need of an auxiliary so able as Swift, by whose pen he and the other ministers might be supported in pamphlets, poems,

* See Inquiry into the Life of Dean Swift, prefixed to Literary Relics, printed in 1789, for Elliot and Kay.

Swift. poems, and periodical papers. In the year 1710 was commenced the *Examiner*; of which Swift wrote 33 papers, beginning his first part of it on the 10th of November 1711. The next year he published the *Conduct of the Allies* ten days before the parliament assembled; and soon afterwards, *Reflections on the barrier Treaty*. The purpose of these pamphlets was to persuade the nation to a peace, by showing that "mines had been exhausted and millions destroyed" to secure the Dutch and aggrandize the emperor, without any advantage whatever to Great Britain. Though these two publications, together with his *Remarks on the Bishop of Sarum's Introduction to the third Volume of his History of the Reformation*, certainly turned the tide of popular opinion, and effectually promoted the designs of the ministry, the best preferment which his friends could venture to give him was the deanery of St Patrick's, which he accepted in 1713. In the midst of his power and his politics he kept a journal of his visits, his walks, his interviews with ministers, and quarrels with his servant, and transmitted it to Mrs Johnson and Mrs Dingley, to whom he knew that whatever befel him was interesting; but in 1714 an end was put to his power by the death of the queen, which broke down at once the whole system of Tory politics, and nothing remained for him but to withdraw from persecution to his deanery.

In the triumph of the Whigs, Swift met with every mortification that a spirit like his could possibly be exposed to. The people of Ireland were irritated against him beyond measure; and every indignity was offered him as he walked the streets of Dublin. Nor was he only insulted by the rabble, but persons of distinguished rank and character forgot the decorum of common civility to give him a personal affront. While his pride was hurt by such indignities, his more tender feelings were also often wounded by base ingratitude. In such a situation he found it in vain to struggle against the tide that opposed him. He silently yielded to it, and retired from the world to discharge his duties as a clergyman, and attend to the care of his deanery. That no part of his time might lie heavy on his hands, he employed his leisure hours on some historical attempts relating to the change of the ministers and the conduct of the ministry; and completed the history of the four last years of the queen, which had been begun in her lifetime, but which he never published. Of the work which bears that title, and is said to be his, Dr Johnson doubts the genuineness; and it certainly is not such as we should have expected from a man of Swift's sagacity and opportunities of information.

In the year 1716 he was privately married to Mrs Johnson by Dr Ashe bishop of Clogher; but the marriage made no change in their situation, and it would be difficult to prove (says Lord Orrery) that they were ever afterwards together but in the presence of a third person. The dean of St Patrick's lived in a private manner, known and regarded only by his friends, till about the year 1720 that he published his first political pamphlet relative to Ireland, intitled *A Proposal for the Universal Use of Irish Manufactures*; which so roused the indignation of the ministry that they commenced a prosecution against the printer, which drew the attention of the public to the pamphlet, and at once made its author popular.

Whilst he was enjoying the laurels which this work had wreathed for him, his felicity, as well as that of his wife, was interrupted by the death of Mrs Van Homrigh, and the publication of his poem called *Cadenus and Vanessa*, which brought upon him much merited obloquy. With Mrs Van Homrigh he became acquainted in London during his attendance at court; and finding her possessed of genius and fond of literature, he took delight in directing her studies, till he got insensibly possession of her heart. From being

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Swift. proud of his praise, she grew fond of his person; and despising vulgar restraints, she made him sensible that she was ready to receive him as a husband. She had wit, youth, beauty, and a competent fortune to recommend her; and for a while Swift seems to have been undetermined whether or not he should comply with her wish. She had followed him to Ireland, where she lived in a house about twelve miles distant from Dublin; and he continued to visit her occasionally, and to direct her studies as he had done in London; but with these attentions she was not satisfied, and at last sent to him a letter written with great ardour and tenderness, insisting that he should immediately accept or refuse her as a wife. His answer, which probably contained the secret of his marriage, he carried himself; and having indignantly thrown it on the lady's table, instantly quitted the house, we believe without speaking to her, and returned to Dublin to reflect on the consequences of his own conduct. These were dreadful. Mrs Van Homrigh survived her disappointment but a few weeks; during which time she cancelled a will that she had made in his favour, and ordered the poem to be published in which Cadenus had proclaimed her excellence and confessed his love.

His patriotism again burst forth in 1724 to obstruct the currency of Wood's halfpence; and his zeal was crowned with success. Wood had obtained a patent to coin 180,000 l. in halfpence and farthings for the kingdom of Ireland; and was about to turn his brass into gold, when Swift, finding that the metal was debased to an enormous degree, wrote letters under the name of *M. B. Drapier* to show the folly of giving gold and silver for coin not worth a third part of its nominal value. A prosecution was carried on against the printer; and lord Carteret, then lord-lieutenant, issued a proclamation, offering L. 300 for discovering the author of the fourth letter. The day after it was published there was a full levee at the castle. The lord-lieutenant was going round the circle, when Swift abruptly entered the chamber, and pushing his way through the crowd, never stopped till he got within the circle; where, with marks of the highest indignation in his countenance, he addressed the lord-lieutenant with the voice of a Stentor, that re-echoed through the room, "So, my lord lieutenant, this is a glorious exploit that you performed yesterday, in issuing a proclamation against a poor shop-keeper, whose only crime is an honest endeavour to save his country from ruin. You have given a noble specimen of what this devoted nation is to hope for from your government. I suppose you expect a statue of copper will be erected to you for this service done to Wood." He then went on for a long time, inveighing in the bitterest terms against the patent, and displaying in the strongest colours all the fatal consequences of introducing that execrable coin. The whole assembly were struck mute with wonder at this unprecedented scene. For some time a profound silence ensued. When lord Carteret, who had listened with great composure to the whole speech, made this fine reply, in a line of Virgil's:

*Res duræ, & regni novitas me talia cogunt
Moliri.*

From this time Swift was known by the name of *the Dean*, and was known by the populace as the champion, patron, and instructor of Ireland.

In 1727 he returned to England; where, in conjunction with Pope, he collected three volumes of miscellanies; and the same year he sent into the world his *Gulliver's Travels*, a production which was read by the high and the low, and filled every reader with a mingled emotion of merriment and amazement. Whilst he was enjoying the reputation of this work, he was suddenly called to a home of sorrow. Poor Stella was sinking into the grave; and after a languishing

H h decay

Swift: decay of about two months, died in her 44th year, on January 28. 1728. How much he wished her life is shown by his papers; nor can it be doubted that he dreaded the death of her whom he loved most, aggravated by the consciousness that himself had hastened it. With her vanished all his domestic enjoyments, and of course he turned his thoughts more to public affairs; in the contemplation of which he could see nothing but what served to increase the malady. The advances of old age, with all its attendant infirmities; the death of almost all his old friends; the frequent returns of his most dispiriting maladies, deafness and giddiness; and, above all, the dreadful apprehensions that he should outlive his understanding, made life such a burden to him, that he had no hope left but a speedy dissolution, which was the object of his daily prayer to the Almighty.

The severity of his temper increasing, he drove his acquaintance from his table, and wondered why he was deserted. In 1732, he complains, in a letter to Mr Gay, that "he had a large house, and should hardly find one visitor if he was not able to hire him with a bottle of wine:" and, in another to Mr Pope, "that he was in danger of dying poor and friendless, even his female friends having forsaken him; which," as he says, "vexed him most." These complaints were afterwards repeated in a strain of yet greater sensibility: "All my friends have forsaken me.

"Vertiginosus, inops, furdus, male gratus amicis.

"Deaf, giddy, helpless, left alone,

"To all my friends a burden grown."

The fits of giddiness and deafness to which he had been subjected from his boyish years, and for which he thought walking or riding the best remedy, became more frequent and violent as he grew old; and the presentiment which he had long entertained of that wretchedness which would inevitably overtake him towards the close of life, clouded his mind with melancholy and tinged every object around him. How miserable he was rendered by that gloomy prospect, we may learn from the following remarkable anecdote mentioned by Mr Faulkner in his letter to lord Chesterfield. "One time, in a journey from Drogheda to Navan, the dean rode before the company, made a sudden stop, dismounted his horse, fell on his knees, lifted up his hands, and prayed in the most devout manner. When his friends came up, he desired and insisted on their alighting; which they did, and asked him the meaning. "Gentlemen," said he, "pray join your hearts in fervent prayers with mine, that I may never be like this oak-tree, which is decayed and withered at top, while the other parts are sound." In 1736, while he was writing a satire called the *Legion Club* against the Irish parliament, he was seized with so dreadful a fit of his malady, that he left the poem unfinished; and never after attempted a composition that required a course of thinking. From this time his memory gradually declined, his passions perverted his understanding, and, in 1741, he became utterly incapable of conversation; and it was found necessary to appoint legal guardians to his person and his fortune. He now lost all sense of distinction. His meat was brought to him cut into mouthfuls; but he would never touch it while the servant staid; and at last, after it stood perhaps an hour, would eat it walking; for he continued his old habit, and was on his feet ten hours a-day. During next year a short interval of reason ensuing, gave hopes of his recovery; but in a few days he sunk into lethargic stupidity, motionless, heedless, and speechless. After a year of total silence, however, when his house-keeper told him that the usual illuminations were preparing to celebrate his birth, he answered, "It is all folly; they had better let it alone." He at last sunk into a perfect silence, which continued till the 29th of October 1745, when he expired without a struggle, in

his 78th year. The behaviour of the citizens on this occasion gave the strongest proof of the deep impression he had made on their minds. Though he had been so many years to all intents and purposes dead to the world, and his departure from that state seemed a thing rather to be wished than deplored, yet no sooner was his death announced, than they gathered from all quarters, and forced their way in crowds into the house, to pay the last tribute of grief to their departed benefactor. Nothing but lamentations were heard all around the quarter where he lived, as if he had been cut off in the vigour of his years. Happy were they who first got into the chamber where he lay, to procure, by bribes to the servants, locks of his hair, to be handed down as sacred relics to their posterity; and so eager were numbers to obtain at any price this precious memorial, that in less than an hour, his venerable head was entirely stripped of all its silver ornaments, so that not a hair remained. By his will, which was dated in May 1740, just before he ceased to be a reasonable being, he left about L. 1200 in specific legacies; and the rest of his fortune, which amounted to about L. 11,000, to erect and endow an hospital for lunatics and idiots. He was buried in the most private manner, according to directions in his will, in the great aisle of St Patrick's cathedral, and, by way of monument, a slab of black marble was placed against the wall, on which was engraved the following Latin epitaph, written by himself:

Hic depositum est corpus

JONATHAN SWIFT, S. T. P.

Hujus Ecclesiæ Cathedralis

Decani:

Ubi sæva indignatio

Ulterius cor lacerare nequit.

Abi, viator,

Et imitare, si poteris,

Strenuum pro virili libertatis vindicem.

Obiit anno (1745)

Mensis (Octobris) die (29.)

Ætatis anno 78.

Swift undoubtedly was a man of native genius. His fancy was inexhaustible; his conceptions were lively and comprehensive; and he had the peculiar felicity of conveying them in language equally correct, free, and perspicuous. His penetration was as quick as intuition; he was indeed the critic of nature; and no man ever wrote so much, and borrowed so little.

As his genius was of the first class, so were some of his virtues. The following anecdote will illustrate his filial piety. His mother died in 1710, as appears by a memorandum in one of the account-books which Dr Swift always made up yearly, and on each page entered minutely all his receipts and expences in every month, beginning his year from November 1. He observed the same method all his lifetime till his last illness. At the foot of that page which includes his expences of the month of May 1710, at the glebe house of Laracor in the county of Meath, where he was then resident, are these remarkable words, which show at the same time his filial piety, and the religious use which he thought it his duty to make of that melancholy event. "*Mem.* On Wednesday, between seven and eight in the evening, May 10. 1710, I received a letter in my chamber at Laracor (Mr Percival and Jo. Beaumont being by) from Mrs F—, dated May 9. with one inclosed, sent by Mrs Worrall at Leicester to Mrs F—, giving an account that my dear mother, Mrs Abigail Swift, died that morning, Monday April 24. 1710, about ten o'clock, after a long sickness: being ill all winter, and lame; and extremely ill about a month or six weeks before her death. I have now lost my barrier between me and death. God grant I may live to be as well prepared for

Swift. for it as I confidently believe her to have been! If the way to heaven be through piety, truth, justice, and charity, she is there. J. S." He always treated his mother, during her life, with the utmost duty and affection; and she sometimes came to Ireland to visit him after his settlement at Laracor.

The liberality of the dean hath been a topic of just encomium with all his admirers; nor could his enemies deny him this praise. In his domestic affairs, he always acted with strict economy. He kept the most regular accounts; and he seems to have done this chiefly with a view to increase his power of being useful. "His income, which was little more than L. 700 *per annum*, he endeavoured to divide into three parts, for the following purposes. First, to live upon one-third of it. Secondly, to give another third in pensions and charities, according to the manner in which persons who received them had lived: and the other third he laid by, to build an hospital for the reception of idiots and lunatics." "What is remarkable in this generous man, is this (says Mr F.), that when he lent money upon bond or mortgage, he would not take the legal interest, but one *per cent.* below it."

His charity appears to have been a settled principle of duty more than an instinctive effort of good nature: but as it was thus founded and supported, it had extraordinary merit, and seldom failed to exert itself in a manner that contributed most to render it beneficial. He did not lavish his money on the idle and the worthless. He nicely discriminated characters, and was seldom the dupe of imposition. Hence his generosity always turned to an useful account: while it relieved distress, it encouraged industry, and rewarded virtue. We dwell with great pleasure on this truly excellent and distinguishing part of the dean's character: and for the sake of his charity we can overlook his oddities, and almost forgive his faults. He was a very peculiar man in every respect. Some have said, "What a man he would have been, had he been without those whims and infirmities which shaded both his genius and his character!" But perhaps the peculiarities complained of were inseparable from his genius. The vigour and fertility of the root could not fail now and then of throwing out superfluous suckers. What produced these, produced also the more beautiful branches, and gave the fruit all its richness.

It must be acknowledged, that the dean's fancy hurried him into great absurdities and inconsistencies, for which nothing but his extraordinary talents and noble virtues, discovered in other instances, could have atoned. The rancour he discovered on all occasions towards the dissenters is totally unjustifiable. No sect could have merited it in the degree in which he always showed it to them; for, in some instances, it bordered on downright persecution. He doubtless had his reasons for exposing their principles to ridicule, and might perhaps have sufficient grounds for some of his accusations against their principal leaders in Ireland; but nothing could justify his virulence against the whole body. In a short poem on one class of dissenters he bestowed a stricture upon Bettsworth, a lawyer eminent for his insolence to the clergy, which, from a very considerable reputation, brought him into immediate and universal contempt. Bettsworth, enraged at his disgrace and loss, went to the dean, and demanded whether he was the author of that poem? "Mr Bettsworth (answered he), I was in my youth acquainted with great lawyers, who, knowing my disposition to satire, advised me, if any scoundrel or blockhead whom I had lampooned should ask, 'Are you the author of this paper?' to tell him that I was not the author; and therefore, I tell you, Mr Bettsworth, that I am not the author of these lines."

Swift. Swift has been accused of irreligion and misanthropy, on account of his *Tale of a Tub*, and his Yahoos in *Gulliver's Travels*; but both charges seem to be ill-founded, or at least not supported by that evidence. The *Tale of a Tub* holds up to ridicule superstitious and fanatical absurdities; but it never attacks the essentials of religion: and in the story of the Yahoos, disgusting we confess, there appears to us as little evidence that the author hated his own species, as in the poems of *Strephon and Chloe*, and the *Ladies Dressing Room*, that he approved of grossness and filth in the female sex. We do not indeed, with his fondest admirers, perceive the moral tendency of the Voyage to the Houyhnhnms, or consider it as a satire admirably calculated to reform mankind; but neither do we think that it can possibly corrupt them, or lead them to think meanly of their rational nature. According to Sheridan, "the design of this apologue is to place before the eyes of man a picture of the two different parts of his frame, detached from each other, in order that he may the better estimate the true value of each, and see the necessity there is that the one should have an absolute command over the other. In your merely animal capacity, says he to man, without reason to guide you, and actuated only by a blind instinct, I will show you that you would be degraded below the beasts of the field. That very form, that very body, you are now so proud of, as giving you such a superiority over all other animals, I will show you, owe all their beauty, and all their greatest powers, to their being actuated by a rational soul. Let that be withdrawn, let the body be inhabited by the mind of a brute, let it be prone as theirs are, and suffered like theirs to take its natural course, without any assistance from art, you would in that case be the most deformed, as to your external appearance, the most detestable of all creatures. And with regard to your internal frame, filled with all the evil dispositions and malignant passions of mankind, you would be the most miserable of beings, living in a continued state of internal vexation, and of hatred and warfare with each other."

"On the other hand, I will show another picture of an animal endowed with a rational soul, and acting uniformly up to the dictates of right reason. Here you may see collected all the virtues, all the great qualities, which dignify man's nature, and constitute the happiness of his life. What is the natural inference to be drawn from these two different representations? Is it not evidently a lesson to mankind, warning them not to suffer the animal part to be predominant in them, lest they resemble the vile Yahoo, and fall into vice and misery; but to emulate the noble and generous Houyhnhnm, by cultivating the rational faculty to the utmost; which will lead them to a life of virtue and happiness."

Such may have been the author's intention; but it is not sufficiently obvious to produce the proper effect, and is indeed hardly consistent with that incapability under which he represents the Yahoos of ever acquiring, by any culture, the virtues of the noble Houyhnhnms.

With respect to his religion, it is a fact unquestionable, that while the power of speech remained, he continued constant in the performance of his private devotions; and in proportion as his memory failed, they were gradually shortened, till at last he could only repeat the Lord's prayer, which he continued to do till the power of utterance for ever ceased. Such a habit as this could not have been formed but by a man deeply impressed with a conviction of the truth and importance of revelation.

The most inexcusable part of Swift's conduct is his treatment of Stella and Vanessa, for which no proper apology can be made, and which the vain attempts of his friends have only tended to aggravate. One attributes his sin-

Swift,
Swimming.

gular conduct to a peculiarity in his constitution; but if he knew that he was incapable of fulfilling the duties of the married state, how came he to tie one of the ladies to himself by the marriage-ceremony, and in the most explicit terms to declare his passion to the other? And what are we to think of the sensibility of a man who, strongly attached as he seems to have been to both, could, without speaking, fling a paper on the table of the one, which "proved (as our author expresses it) her death-warrant," and could throw the other, his beloved Stella, in her last illness, into unspeakable agonies, and "never see her more, for only adjuring him, by their friendship, to let her have the satisfaction of dying at least, though she had not lived, his acknowledged wife?" Another apologist insinuates, upon something like evidence, that Stella bore a son to Swift, and yet labours to excuse him for not declaring her his wife, because she had agreed at the marriage that it should remain a secret from all the world unless the discovery should be called for by *urgent necessity*; but what could be meant by the term *urgent necessity*, unless it alluded to the birth of children, he confesses that it would be hard to say. The truth we believe to be what has been said by Johnson, that the man whom Stella had the misfortune to love was fond of singularity, and desirous to make a mode of happiness for himself, different from the general course of things and the order of Providence; he wished for all the pleasures of perfect friendship, without the uneasiness of conjugal restraint. But with this state poor Stella was not satisfied; she never was treated as a wife, and to the world she had the appearance of a mistress. She lived sullenly on, hoping that in time he would own and receive her. This, we believe, he offered at last to do, but not till the change of his manners and the depravation of his mind made her tell him, that "it was too late."

The natural acrimony of Swift's temper had been increased by repeated disappointments. This gave a splenetic tincture to his writings, and amidst the duties of private and domestic life it too frequently appeared to shade the lustre of his more eminent virtues. — The dean hath been accused of avarice, but with the same truth as he hath been accused of infidelity. In detached views, no man was more liable to be mistaken. Even his genius and good sense might be questioned, if we were only to read some passages of his writings. To judge fairly and pronounce justly of him as a man and as an author, we should examine the uniform tenor of his disposition and conduct, and the general nature and design of his productions. In the latter he will appear great, and in the former good; notwithstanding the puns and puerilities of the one, and the absurdities and inconsistencies of the other.

SWIFT, in ornithology. See HIRUNDO.

SWIMMING, the art of suspending one's self on water, and at the same time making a progressive motion thro' it.

1
Swimming
not natural
to man.

As swimming is not natural to man, it is evident that at some period it must have been unknown among the human race. Nevertheless there are no accounts of its origin to be found in the history of any nation; nor are there any nations so barbarous but that the art of swimming is known among them, and that in greater perfection than among civilized people. It is probable, therefore, that the art, though not absolutely natural, will always be acquired by people in a savage state from imitating the brute animals, most of whom swim naturally. Indeed so much does this appear to be the case, that very expert swimmers have recommended it to those who wished to learn the art, to keep some frogs in a tub of water constantly beside them, and to imitate the motions by which they move thro' that element.

2
Depends on
a simple
principle.

The theory of swimming depends upon one very simple principle; namely, that if a force is applied to any

body, it will always move towards that side where there is the least resistance. Thus, if a person standing in a boat pushes with a pole against the side or any other part of the vessel in which he stands, no motion will ensue; for as much as he presses in one direction with the pole, just so much does the action of his feet, on which the pressure of the pole must ultimately rest, push the vessel the other way: but if, instead of the side of the vessel, he pushes the pole against the shore, then only one force acts upon it, namely, that of the feet; which being resisted only by the fluid water, the boat begins to move from the shore. Now the very same thing takes place in swimming, whether the animal be man, quadruped, bird, or fish. If we consider the matter simply, we may suppose an animal in such a situation that it could not possibly swim: thus, if we cut off the fins and tail of a fish, it will indeed float in consequence of being specifically lighter than the water, but cannot make any progressive motion, or at least but very little, in consequence of wriggling its body; but if we allow it to keep any of its fins, by striking them against the water in any direction, the body moves the contrary way, just as a boat moves the contrary way to that in which the oars strike the water. It is true, that as the boat is but partly immersed in the water, the resistance is comparatively less than when a frog or even any other quadruped swims; but a boat could certainly be rowed with oars tho' it was totally immersed in water, only with less velocity than when it is not. When a man swims, he in like manner strikes the water with his hands, arms, and feet; in consequence of which the body moves in a direction contrary to the stroke. Upon this principle, and on this only, a man may either ascend, descend, or move obliquely, in any possible direction in the water. One would think, indeed, that as the strength of a man's arms and legs is but small, he could make but very little way by any stroke he could give the water, considering the fluidity of that element. Nevertheless it is incredible what expert swimmers will perform in this way; of which Mr Forster gives a most remarkable instance in the inhabitants of Otaheite; whose agility, he tells us, was such, that when a nail was thrown overboard, they would jump after it into the sea, and never fail to catch it before it came to the bottom.

As to the practice of swimming, there are but few directions which can be given. The great obstacle is the natural dread which people have of being drowned; and this it is impossible to overcome by any thing but accustoming ourselves to go into the water. With regard to the real danger of being drowned, it is but little; and on innumerable occasions arises entirely from the terror above mentioned, as will appear from the following observations by Doctor Franklin.

"1st, That though the legs, arms, and head, of a human body, being solid parts, are specifically somewhat heavier than fresh water, yet the trunk, particularly the upper part, from its hollowness, is so much lighter than water, as that the whole of the body, taken together, is too light to sink wholly under water, but some part will remain above until the lungs become filled with water; which happens from drawing water into them instead of air, when a person in the fright attempts breathing while the mouth and nostrils are under water.

"2dly, That the legs and arms are specifically lighter than salt water, and will be supported by it; so that a human body would not sink in salt water though the lungs were filled as above, but from the greater specific gravity of the head.

"3dly, That therefore a person throwing himself on his back in salt water, and extending his arms, may easily lie so

3
Observations by
Dr Franklin.

Swimming. so as to keep his mouth and nostrils free for breathing; and by a small motion of his hands may prevent turning, if he should perceive any tendency to it.

"4thly, That in fresh water, if a man throws himself on his back near the surface, he cannot long continue in that situation, but by a proper action of his hands on the water. If he uses no such action, the legs and lower part of the body will gradually sink till he comes into an upright position; in which he will continue suspended, the hollow of the breast keeping the head uppermost.

"5thly, But if in this erect position the head is kept upright above the shoulders, as when we stand on the ground, the immersion will, by the weight of that part of the head that is out of the water, reach above the mouth and nostrils, perhaps a little above the eyes; so that a man cannot long remain suspended in water with his head in that position.

"6thly, The body continued suspended as before, and upright, if the head be leaned quite back, so that the face looks upwards, all the back part of the head being then under water, and its weight consequently in a great measure supported by it, the face will remain above water quite free for breathing, will rise an inch higher every inspiration, and sink as much every expiration, but never so low as that the water may come over the mouth.

"7thly, If therefore a person unacquainted with swimming, and falling accidentally into the water, could have presence of mind sufficient to avoid struggling and plunging, and to let the body take this natural position, he might continue long safe from drowning, till perhaps help would come; for as to the clothes, their additional weight while immersed is very inconsiderable, the water supporting it; though when he comes out of the water, he would find them very heavy indeed."

4
His method
of learning
to swim,

The method of learning to swim is as follows: The person must walk into water so deep that it will reach to the breast. He is then to lie down gently on the belly, keeping the head and neck perfectly upright, the breast advancing forward, the thorax inflated, and the back bent; then withdrawing the legs from the bottom, and stretching them out, strike the arms forwards in unison with the legs. Swimming on the back is somewhat similar to that on the belly; but with this difference, that although the legs are employed to move the body forwards, the arms are generally unemployed, and the progressive motion is derived from the movement of the legs. In diving, a person must close his hands together, and, pressing his chin upon his breast, make an exertion to bend with force forwards. While in that position, he must continue to move with rapidity under the surface; and whenever he chooses to return to his former situation, he has nothing to do but bend back his head, and he will immediately return to the surface.

It is very common for novices in the art of swimming to make use of corks or bladders to assist in keeping the body above water. Some have utterly condemned the use of these; however, Dr Franklin allows that they may be of service for supporting the body while one is learning what is called the *stroke*, or that manner of drawing in and striking out the hands and feet that is necessary to produce progressive motion. "But (says he) you will be no swimmer till you can place confidence in the power of the water to support you: I would therefore advise the acquiring that confidence in the first place, especially as I have known several who, by a little of the practice necessary for that purpose, have insensibly acquired the stroke, taught as it were by nature.

5
And of ac-
quiring con-
fidence.

"The practice I mean is this: Choosing a place where the water deepens gradually, walk coolly into it till it is up to your breast: then turn round your face to the shore,

and throw an egg into the water, between you and the shore; it will sink to the bottom, and be easily seen there, if the water is clear. It must lie in the water so deep as that you cannot reach it to take it up but by diving for it. To encourage yourself in order to do this, reflect that your progress will be from deeper to shallower water; and that at any time you may, by bringing your legs under you, and standing on the bottom, raise your head far above the water: then plunge under it with your eyes open, throwing yourself towards the egg, and endeavouring, by the action of your hands and feet against the water, to get forward till within reach of it. In this attempt you will find that the water buoys you up against your inclination; that it is not so easy a thing to sink as you imagined; that you cannot but by active force get down to the egg. Thus you feel the power of the water to support you, and learn to confide in that power; while your endeavours to overcome it, and to reach the egg, teach you the manner of acting on the water with your feet and hands; which action is afterwards used in swimming to support your head higher above water, or to go forward through it."

As swimming is a healthy exercise and a pleasant amusement, and as a dexterity in it may frequently put it in a man's power to save his own life and the lives of his fellow-creatures, perhaps of his dearest friends, it can neither be useless nor uninteresting to consider a few of the evolutions which a swimmer must be master of, that he move in any direction without difficulty, without danger, and without being unnecessarily fatigued.

There are several different ways of turning one's self in swimming. You may do it in this way: Turn the palm of the right hand outwards, extend the arm in the same manner, and make a contrary movement with the left hand and left arm; then, by a gradual motion, incline your head and whole body to the left side, and the evolution will be finished. There is another way which is easier still: Bend your head and body toward that side to which you are going to turn. If you wish to turn to the left, incline the thumb and the right hand toward the bottom, bend the fingers of the right hand, stretch it out, and use it for driving away the water sidewise, or, which is the same thing, for pushing yourself the contrary way. At the same time, with your left hand, the fingers being close, push the water behind you, and all at once turn your body and your face to the left, and the manœuvre will be accomplished. If you wish to turn to the right, you must do with your right hand what you did with your left, and with your left what you did with your right. You must be careful when turning yourself never to stretch out your legs, and be sure that the water be so deep that you be in no danger of hurting yourself.

When you are swimming on your belly, and wish to turn on your back, draw your feet in quickly, and throw them before you; stretch out your hands behind you, and keep your body firm and steady. When you wish to turn from swimming on your back, fold your feet at once under your body as if you were throwing them to the bottom, and at the same instant dart your body forwards, that you may fall upon your belly.

In swimming, the eyes ought to be turned towards heaven. This is a most important rule, and to the neglect of it many of the accidents which befall swimmers are owing. For when they bend their eyes downwards, they insensibly bend their head too, and thus the mouth being too deep in the water, may admit a quantity of it in breaking; besides, the more the body is stretched, it covers a greater part of the surface of the water, and consequently its specific gravity is less. Any person who will make the experiment will find

Swimming.

6
Swimming
a pleasant
and useful
exercise.

7
How to
turn to the
right or
left.

8
How to
turn from
the belly to
the back.

9
The eyes
ought to
be turned
towards
heaven.

Swimming. it impossible to dive while he keeps his head erect and his eyes fixed on the heavens (A).

10
How to
swim on
the back,

The easiest posture in swimming is lying on the back. When you wish to swim in this posture, lay yourself softly on your back, and raise your breast to the surface of the water, keeping your body extended in the same line. Put your hands easily over the upper part of your thighs, and throw out your legs and draw them in alternately, keeping them within two feet of the surface. In this way you may advance in any direction you please. You may perhaps not like having so much of your head under water; there is, however, no way of swimming so easy, so safe, and so little fatiguing. If you wish to swim with great rapidity, you may use your arms as well as your feet; and you will find this the easiest way of breaking the force of the waves.

11
And ad-
vance for-
wards.

In swimming on the back, one may advance forward as well as backward. For this purpose the body must be kept straight and extended; the breast inflated, so that the hollow of the back may assume a semicircular form. The hands must recline over the upper parts of the thighs. It is also necessary to raise the legs one after another, and draw them in strongly towards the hams, and then leave them suspended in the water. This way of swimming is not only pleasant, but may serve to rest you when fatigued.

12
How to
swim on
one side.

When you are tired with swimming on your back and belly, you may swim on one side. When you wish to do this, sink a little your left side and raise your right; you will immediately find yourself on your left side. Move then your left hand without either raising or sinking it; you have only to stretch it and draw it back, as in a straight line, on the surface of the water. Independent of the pleasure which this kind of motion will give you, you will have the satisfaction of seeing both sides of the river.

13
How to
swim on
the belly
without
the assist-
ance of the
hands.

It is possible to swim on the belly without the assistance of the hands. For this purpose you must keep your breast erect, your neck straight, and fix your hands behind your head, or upon your back, while you move forward by employing your feet. This way is not without its advantages. It is an excellent resource when the arms are seized with a cramp, or with any indisposition which makes it painful to exert them. This in some cases may be preferable to swimming on the back; for while in that attitude, one cannot see before them without turning every instant. If one of your legs be seized with a cramp, take hold of it with the hand opposite to it, and use the other hand and leg to advance or support yourself.

14
How to
swim with
the hands
joined.

A very ancient and graceful mode of swimming, is that of swimming with the hands joined. When you wish to put this in practice, join your hands, keeping the thumbs and fingers towards heaven, so that they may appear above the water; then draw them back and push them forwards alternately from your breast. This method of swimming may be useful in several circumstances, but above all if you are entangled with grass or weeds. Your hands will then open a passage for you.

15
With the
hands ele-
vated.

As a person may sometimes have occasion to carry something in his hand in swimming, which he is anxious to pre-

serve from the water, he may swim easily with one hand and hold a parcel in the other, as Cæsar swam with his Commentaries at Alexandria; or one may swim with both hands elevated. To perform this well, the swimmer must raise his breast, and keep it as much inflated as he can, at the same time that he supports the arms above the water. It must not be concealed, that this method of swimming is attended with some danger to one who is not dexterous at the art; for if one should imprudently draw in his breast, when his arms are raised, he would immediately sink to the bottom.

Every one knows that when a man plunges into the water, and when he has reached the bottom, he has nothing to do but to give a small stroke with his foot against the ground, in order to rise; but an experienced swimmer, if he misses the ground, has recourse to another expedient, which is very pretty, and which has not been considered with sufficient attention. We suppose him at a considerable depth, when he perceives that he cannot reach the bottom. In such a case, he first puts his hands before his face, at the height of his forehead, with the palms turned outwardly; then holding the fore part of his arm vertically, he makes them move backwards and forwards from right to left; that is to say, these two parts of his arms, having the elbow as a kind of pivot, describe very quickly, both the hands being open, and the fingers joined, two small portions of a circle before the forehead, as if he would make the water retire, which he in fact does; and from these strokes given to the water, there results an oblique force, one part of which carries the swimmer upwards.

There are many artificial methods of supporting one's self in water, but we have not room to describe them.—Those who wish to see a full account of them may consult the *Encyclopédie Methodique*.

SWIMMING of Fish. A great proportion of the inhabitants of the waters have an air-bladder, by which they poise themselves. Their movements chiefly depend upon their tail. See *COMPARATIVE ANATOMY*, n° 147, 155; and *ICHTHYOLOGY*, n° 3.

SWINDLER, a word which has been lately adopted into the English language, derived from the German word *schwindel*, "to cheat." Swindling has now become so common in several of the great towns of this country, that it is unfortunately too well known to require any description.

SWINE, in zoology. See *Sus*.

SWINE-Stone. See *Swine-STONE*.

SWINGING, a kind of exercise strongly recommended to persons in consumption by some physicians, and disapproved of by others. See *MEDICINE*, p. 224.

SWING-TREE of a waggon, is the bar fastened across the fore-guide, to which the traces of the horses are fastened.

SWING-Wheel, in a royal pendulum, that wheel which drives the pendulum. In a watch or balance clock it is called the crown-wheel.

SWINGLE, in the fire-works in England, the wooden spoke which is fixed to the barrel that draws the wire, and which,

(A) An interesting question occurs here, which deserves to be considered. Since the body, when spread upon the surface, can be supported with so little exertion, and frequently without any at all, as in swimming on the back, how comes it to pass that a person when drowned sinks and frequently rises again some time afterwards? The reason is this: In the act of drowning, the lungs are filled with water, and consequently the body, being specifically heavier, sinks. It is well known that the human body contains a great quantity of air: this air is at first compressed by the water; and while this is the case the body remains at the bottom: but as soon as the air by its elasticity endeavours to disengage itself from the compression, the body is swelled and expanded, becomes specifically lighter than the water, and consequently rises to the top.

Switz,
Switzer-
land.

Switzer-
land.

which, by its being forced back by the cogs of the wheel, is the occasion of the force with which the barrel is pulled.

SWITZ, or SCHWEITS, the capital of one of the cantons of Switzerland, to which it gives name, seated on the east side of the lake Lucern, in N. Lat. 46. 55. E. Long. 8. 30.

SWITZERLAND, or SWISSERLAND, is bounded on the north by Swabia; on the east by Tirol; on the south by Savoy and the Milanese; and on the west by France, being about 260 miles long and 100 broad. It is divided into 13 cantons, viz. *Berne, Zurich, Schaffhausen, Basil, Lucerne, Underwalden, Uri, Switz, Friburg, Zug, Soleure, Glaris, and Appenzel*. See these articles.

The Swifs were anciently called *Helvetii*; and being subdued by the Romans, they continued in subjection to that power till the empire declined, when they became a part of the kingdom of Burgundy. After that they fell under the dominion of the Franks, then of the Germans; but being oppressed by the latter, they threw off the yoke, and erected several states and republics, which, at the treaty of Westphalia in 1648, were recognized as free and independent. The cantons of Switz, Uri, and Underwalden, having, as early as the year 1308, entered into a confederacy in the canton of Switz, and having also obtained their first victory, in 1315, over Leopold archduke of Austria, in the same canton, its name was given to the whole confederacy, which it still retains. The other cantons successively acceded to this association, but some of them not until upwards of 100 years after. With respect to the government and constitution of these cantons, some of them are aristocracies and some democracies. In the former, both the legislative and executive power is lodged in the burghers or citizens of the capital of each canton; and of these there are seven, viz. *Zurich, Berne, Basil, Friburg, Soleure, and Schaffhausen*; an account of the most important of which may be seen under their respective names. In the others, the legislative power is lodged in the whole body of the people; and every male above 16, whether master or servant, has a vote in making laws and in the choice of magistrates. For what concerns the whole Helvetic body, there are diets ordinary and extraordinary: the former are held annually, and the others upon particular emergencies; and both are summoned by the city of Zurich, which appoints the time and place of their meetings. Besides the general diets since the Reformation, there have been particular diets of the two religions, at which all public affairs of consequence that regard the two parties are treated separately; for though a sense of their common interest obliges them to study to maintain the league and union, yet it is certain, that the mutual confidence between the cantons, is in some measure lost through the zeal of each party for their particular opinions, especially of the Roman Catholics. The annual general diets are held always at Frauenfeld or Baden, principally to regulate the affairs of the common bailiages. Lucern takes the lead of the Roman Catholic cantons, being the most powerful of that denomination; but Zurich, though less powerful than that of Berne, takes the precedence of all the other cantons, both Protestant and Popish. These cantons do not make one commonwealth, but are so many independent states, united together by strict alliances for their mutual defence. The extraordinary diets or congresses are held at Aldorf. Each canton usually deputed two envoys both to the ordinary and extraordinary, to which also the abbot and the town of St Gall, and the town of Biel, send representatives as allies. To the 13 cantons belong in common 21 bailiages, two towns, and two lordships. The allies, or incorporated places as they are called, are the abbot and town of St Gall, the three Grison leagues, the republic of the Valais, the towns of Muhlhausen and Biel, the

principality of Neuenberg or Neufchatel, Geneva, and the bishop of Basil. Of these the abbot and town of St Gall, and the town of Biel, are regarded as members of the Helvetic body, but the rest only as allies.

As to the air, soil, and produce of Switzerland, that part of the canton of Berne to the east of the lake of Geneva, together with the cantons of Uri, Switz, Underwalden, Glaris, Appenzel, and part of the canton of Lucern, consist of stupendous mountains, whose tops are said to be from 9000 to 12,000 feet above the level of the sea, consisting of craggy inaccessible rocks, of which some are quite bare, while others are always covered with ice and snow. Among the mountains are many excellent medicinal and other springs, cold and warm baths, water-falls, craggy precipices, deep narrow valleys, and caverns. They yield also a great variety of herbs, thickets, and bushes, in the upper parts; and in the lower, rich pastures and woods. The highest are those in the canton of Uri. Many of the valleys are covered with lakes, or watered by brooks and rivers. In some of them are towns, villages, woods, vineyards, and corn-lands. Both on the mountains and in the valleys the air is extremely cold in winter; but in summer it is very pleasant, cool, and refreshing on the former, but excessively hot in the latter. Sometimes it is winter on the north side of a mountain when it is summer on the other; nay, flowers may be gathered sometimes with one hand, and snow with the other. Prodigious masses of ice and snow often fall from them in winter, and do a great deal of damage (see *GLACIER*); and most of the streams and rivers take their rise from the thawing of the ice and snow on their sides and tops. From the rising or descending of the clouds, with which they are commonly enveloped, the inhabitants can, for the most part, pretty exactly foretel the changes of the weather; so that they serve them instead of weather-glasses. The other and lower parts of Switzerland are very pleasant and fertile, being diversified with vineyards, corn-fields, meadows, and pasture-grounds. The mountains in these are but mole-hills in comparison of the others: there is neither snow nor ice on them in summer; and they frequently afford not only good pasturage, but arable ground. Many petrifications are found both among these and the others, with a variety of fossils. The sands of the rivers yield gold-dust, particularly those of the Rhine, the Emmet, and the Aar, the Reufs, the Arve, and the Inn. The metals of this country being generally found to be brittle, the only mines that are worked are a few iron ones. In the lower parts of Switzerland they sow rye, oats, barley, spelt, flax, and hemp. Wines of various sorts are also produced in some of them, with a variety of fruits. Of wood for fuel and other uses there is generally plenty; in some places, however, they are obliged to burn sheeps dung, and in others a kind of heath and small shrubs. In the valleys they cultivate saffron with success. The Switzers derive their principal subsistence from their flocks and herds of cattle, which in summer graze upon the mountains. Their cheese is much esteemed, especially that of Berne and Griers in the canton of Friburg. Great numbers of horses are also bred here, and bought up for the French cavalry. Besides the above mentioned rivers, the Rhone and the Tefin have their sources in this country. The lakes are very numerous; but the chief are those of Geneva, Neufchatel, Biel, Zurich, Thun, Brien, Constance, and Lucern. Both rivers and lakes abound with fish, and afford a cheap water-carriage. Switzerland is not so populous as many other countries in Europe; and the Popish cantons less so than the Protestant. The total number of the inhabitants is computed at two millions.

The language generally spoken here is the German, in which also all public affairs are transacted; but in those parts

Switzer-
land.

parts of the country that border on Italy or France, a corrupt French or Italian prevails. The two predominant religions are Calvinism and Popery. Of the former are the cantons of Zurich and Berne, the town of St Gall, Geneva, Muhlhausen, and Biel, the principality of Neufchatel, the greater part of Basil, Schaffhausen, the country of the Grisons, the Thurgau, Toggenburg, Glaris, and the Rhine valley; the frontiers of Appenzel, with a small part of Solothurn, and some places in the countries of Baden and Sargans. The rest of the Swiss cantons, allies and dependents, are Popish. For the education of youth there is an university at Basil, and academies at Zurich, Berne, Lausanne, and Geneva, besides gymnasiums and scholæ illustres, both in the Popish and Protestant cantons. There are also societies among them for the improvement of the German language and the sciences.

The principal manufactures are snuff and tobacco, linen of several sorts, lace, thread, silk, and worsted stockings, neckcloths, cotton stuffs, gloves, handkerchiefs, silks of several sorts, gold and silver brocades, a variety of woollen manufactures, hats, paper, leather of all sorts, earthen wares, porcelain, toys, watches, clocks, and other hardwares, &c. The trade of Switzerland is greatly promoted by many navigable lakes and rivers. In some of the above manufactures, and in cheese, butter, sheep, horses, black cattle, hides, and skins, the exports are considerable; and as the imports are chiefly grain and salt, with some American and Asiatic goods, there is probably a large balance in their favour. In some parts of Switzerland dress is restrained by sumptuary laws.

The public revenues are in general very inconsiderable, arising chiefly from the usual regalia, appropriated everywhere to the sovereign, the demesnes, and public granaries, voluntary contributions, the sale of salt, and a land-tax; in the Protestant cantons, from the church-lands also that were seized at the Reformation. Except in Zurich, Berne, Basil, and Schaffhausen, where the people are more industrious, have a greater trade, and are richer than in the others, they defray the ordinary charges, and that is all.

The cantons never keep any standing troops, except for a few garrisons; but their militia is reckoned to be the best regulated of any in Europe. Every male from 16 to 60 is enrolled, and about one-third of them regimented. They must all provide themselves with arms, clothing, and accoutrements, and appear on the stated days for exercise; and the several cantons and districts must be furnished with a sufficient train of artillery, and all the other implements of war. The Switzers of the several cantons are allowed to engage in the service of such foreign princes and states as are in alliance with those cantons, or with whom they have made a previous agreement. Such states, paying an annual subsidy to the respective cantons, are allowed to make levies. Every man enlists voluntarily, and for what number of years he pleases; at the expiration of which he is at liberty to return home. A great many thus always returning from foreign service, Switzerland is never unprovided with able and experienced officers and soldiers. With respect to their character, they are a brave, honest, hospitable, hardy people; very true to their engagements, friendly, and humane. In short, there is not a people in Europe whose national character is better. In their persons they are generally tall, robust, and well-made; but their complexions are none of the best, and those that live in the neighbourhood of the mountains are subject to wens. The women are said to be generally handsome and well-shaped, sensible and modest, yet frank, easy, and agreeable in conversation. Few of the peasants are miserably poor; many of them are rich, especially in the Protestant cantons, and that of Berne in particular.

SWIVELS, a kind of ring made to turn round in a staple, or other ring. These are used when a ship lies at her moorings; also in tedders for cattle, that they may turn round without unwarping the tedder. Swivels
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Sydenham.

SWIVEL-Cannon, is a small piece of artillery belonging to a ship of war, which carries a shot of half a pound, and is fixed in a socket on the top of the ship's side, stern, or bow, and also in her tops. The trunnions of this piece are contained in a sort of iron crotch, of which the lower end terminates in a cylindrical pivot resting in the socket, so as to support the weight of the cannon. The socket is bored in a strong piece of oak, reinforced with iron hoops, in order to enable it to sustain the recoil. By means of this frame, which is called the *swivel*, and an iron handle on its cable, the gun may be directed by the hand to any object. It is therefore very necessary in the tops, particularly when loaded with musket-balls, to fire down on the upper decks of the adversary in action.

SWOONING. See MEDICINE, n° 274.

SWORD, an offensive weapon worn at the side, and serving either to cut or stab. Its parts are, the handle, guard, and blade; to which may be added the bow, scabbard, pommel, &c.

SWORD of State, which is borne before the king, lords, and governors of counties, cities, or boroughs, &c. For or before the king, it ought to be carried upright; the hilt as low as the bearer's waist, the blade up between his eyes. For or before a duke, the blade must decline from the head, and be carried between the neck and the right shoulder. For or before an earl, the blade is to be carried between the point of the shoulder and the elbow: and for or before a baron, the blade is to be borne in the bend of the arm. This ceremonial form no less denotes the dignity of a governor than the coronet set on his coat of arms.

SWORD-Fish. See XIPHIAS.

SWORN BROTHERS (*fratres jurati*), persons who, by mutual oath, covenanted to share each others fortune. Formerly, in any notable expedition to invade and conquer an enemy's country, it was the custom for the more eminent soldiers to engage themselves by reciprocal oaths to share the rewards of their service. This practice gave occasion to the proverb of *sworn brothers* or *brethren in iniquity*, because of their dividing plunder and spoil.

SYCAMORE-TREE, in botany. See ACER.

SYCOPHANT, an appellation given by the ancient Athenians to those who informed of the exportation of figs contrary to law; and hence it is still used in general for all informers, parasites, flatterers, cheats, &c.

SYDENHAM (Dr Thomas), an excellent English physician, was the son of William Sydenham of Winford Eagle in Dorsetshire, and was born there about the year 1624. He studied at Magdalen-hall, Oxford; but left that university when Oxford was garrisoned for king Charles I. and went to London: where, becoming acquainted with Dr Thomas Cox, an eminent physician, that gentleman persuaded him to apply himself to the study of physic; accordingly, after the garrison was delivered up to the parliament, he retired again to Magdalen-hall, entered on the study of medicine, and in 1648 was created bachelor of physic. Soon after, he was made a fellow of All-Souls college, and continued there several years: when, leaving the university, he settled at Westminster, became doctor of his faculty at Cambridge; grew famous for his practice; and was the chief physician in London from the year 1660 to 1670; at which period he began to be disabled by the gout. He died in 1689. His works are highly esteemed both at home and abroad. He was famous for his cool regimen in the small-pox; for giving the bark after the paroxysm in agues; and for

Syderopæcilus
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Sylla.

for his use of laudanum. He regulated his practice more by his own observations and inquiries, than by the method either of his predecessors or contemporaries.

SYDEROPÆCILUS, in natural history, the name of a stone mentioned by the ancients. It was found in Arabia, and seems to have obtained this name from its being spotted with a ferruginous colour. The descriptions of the ancients are, however, in this, as in many other instances, too short to suffer us to guess what stone they meant.—This might possibly be a granite with spots of this peculiar colour.

SYENE, an ancient city of Egypt, situated, according to Mr Bruce, in north latitude $24^{\circ} 0' 45''$. Pliny and Strabo both say that it lay directly under the tropic of Cancer. Whether Mr Bruce's authority be sufficient to overturn the evidence of Pliny and Strabo, we shall leave to others to determine.

Syene is remarkable for being the place where the first attempt was made to measure the circumference of the earth. This was done by Eratosthenes, whom Ptolemy Euergetes had invited from Athens to Alexandria. In this attempt two positions were assumed, viz. that Alexandria and Syene were exactly 5000 stadia distant from each other, and that they were precisely under the same meridian; but both these are denied by Mr Bruce, who has made many observations on the subject, which our limits will not allow us to take notice of at present. He tells us, that there is at Asum an obelisk erected by Ptolemy Euergetes, the patron of Eratosthenes, without hieroglyphics, directly facing the south, with its top first cut into a narrow neck, then spread out like a fan into a semicircular form, with pavements curiously levelled to receive the shade, and make the separation of the true shadow from the penumbra as distinct as possible. This is supposed by Mr Bruce to have been constructed with a design to vary the experiment of Eratosthenes with a larger radius; and the inquiry concerning the dimensions of the earth, in our author's opinion, was the occasion of many obelisks being erected in this kingdom; a demonstration of which is, that the figure of the top is varied; being sometimes very sharp, and sometimes a portion of a circle, in order to get rid of the great impediment arising from the penumbra, which makes it difficult to determine the length of the shadow with precision. It is now called *Affouan*.

SYLLA (Lucius Cornelius), was descended from the illustrious family of the Scipios. His behaviour in his younger years by no means corresponded with the excellent education which he had received. But debauchery, instead of bringing along with it infamy and ruin, its usual attendants, served only to increase the wealth of this fortunate Roman; for Nocopolis, a rich courtesan, whose affections he had gained, left him heir to her great estate.—He learned the art of war under Marius, whom he attended to Numidia in quality of questor. Though hitherto unaccustomed to arms, he became in a short time the most skilful soldier in the army, while by his polite and obliging behaviour he gained the love and esteem of every body. His courage and dexterity contributed a great deal towards the success of the war; it was his eloquence in particular that persuaded Bocchus to deliver up Jugurtha. He served afterwards in the social war, where his actions entirely eclipsed those of every other commander. As a reward for this conduct he was raised to the prætorship. It is pretended by some that Sylla purchased this dignity; and that when he threatened one day to make use of the powers of his office against Strabo the father of Pompey, that Roman replied with a smile, "You are in the right to say so; your office is certainly *yours*, since you purchased it." Be this as it may,

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after the conclusion of the social war he was made consul, and soon after declared general of the army which was to be sent against Mithridates king of Pontus. Marius, at that time the most renowned of the Roman generals, expected that the management of this war would have been committed to him, and was therefore much exasperated at the disappointment. The people were persuaded by his intrigues to reverse the former decree, and substitute him in place of Sylla. Upon this he sent down officers to take the command of the army; but Sylla by this time had gained over the soldiers; who, instead of obeying the decree of the people, slew Marius's officers, and intreated Sylla to lead them instantly to Rome. Accordingly he entered the city sword in hand, slew Sulpicius the consul, obliged Marius to flee, new-modelled the laws, and afterwards marched into the East, and immediately laid siege to Athens; for that city, together with the rest of Greece, had fallen into the power of Mithridates. He wrote to the Amphyctions, who were assembled at Delphi, to send him all the gold which was deposited in the temple of Apollo, because he stood in need of money; promising, at the same time, to restore it again at the end of the war. When he received this treasure, he observed, with an air of railery, that he now no longer despaired of victory, since the gods themselves furnished him with money to pay his troops. Famine soon obliged the Athenians to think of a surrender. Their ambassadors waited on Sylla, and began to harangue about Theseus and Codrus, and Marathon and Salamis, —when he interrupted them, and exclaimed, "Go, repeat these fine orations in your schools; I have come hither, not to learn your history, but to chastise rebels." Athens was at last taken by assault, and Sylla was upon the point of destroying it, when he recollected its ancient glory, and spared (as he said) the living for the sake of the dead. After burning the Piræus, he gained two decisive victories over the generals of Mithridates. In the second battle, which was fought at Orchomenus, he was almost defeated; his troops began to flee, when, leaping from his horse, he snatched up a standard, and advanced against the enemy, crying out, "I will die here gloriously; and, soldiers, when you are asked where you abandoned your general, answer, At Orchomenus." This reproach recalled the courage of the Romans; they followed him to the charge, and gained a complete victory. Mithridates, humbled by these disasters, sent ambassadors to sue for peace.

Mean time Cinna had declared against Sylla in Italy; and Marius returning from banishment, had taken the most severe vengeance on all his enemies. Sylla was declared a traitor; his laws were reversed, his friends murdered, and the government new-modelled. The news of these transactions induced Sylla to conclude a treaty with Mithridates, and march directly to Rome. His approach terrified the Romans. Marius and Cinna were both dead; but the consuls made vigorous preparations to oppose him. A civil war was begun; but Sylla in the end subdued all his enemies, and entirely ruined the Marian faction. He entered Rome at the head of his victorious army, and publicly assumed the surname of *Happy*. Happy, indeed, had he ceased to live when he ceased to conquer. The remainder of his life contains nothing else but a catalogue of the most abominable cruelties. He declared that every one who expected pardon for their late offences, must gain it by destroying the enemies of the state. The sword of the assassin was thus unsheathed, and murder encouraged as the path to power and distinction. The noblest of the Romans were everywhere massacred; slaves were rewarded for cutting off their masters; children were seen dragging their parents to execution; and brothers claiming a recompense for the murder

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Sylla.

Sylla
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Syllabus.

der of brothers. Sylla ordered 8000 wretches, who had thrown themselves upon his clemency, to be butchered in the Campus Martius. In the mean time he entered the senate-house, and began to talk with great coolness about his exploits. The senate, alarmed at the horrid outcries of the sufferers, at first thought that the city was given up to be plundered; but Sylla informed them, with an unembarrassed air, that it was only some criminals punishing by his orders, and that they needed not be apprehensive about their own fate.

To carry on these cruelties with the appearance of justice, he commanded the people to elect him dictator. He kept this office for more than two years; and then, to the amazement of all, laid it down, and offered to stand his trial before the people. Soon afterwards he retired into the country, and plunged headlong into every kind of debauchery. Nor did he relinquish his cruelty together with his power: His wife falling ill in the midst of a sumptuous feast, he divorced her immediately; and ordered her to be carried away, lest her death should interrupt the festivity of his house.

He died of the morbus pedicularis, in the 60th year of his age. His body, according to his orders, was burnt. A little before his death he wrote his epitaph; the tenor of which was, that no man had ever exceeded him in doing good to his friends or injury to his enemies.

His person was elegant, his air noble, his manners easy and apparently sincere. He was fond of pleasure, but fonder of glory; indulging without scruple in sensual delights, but never suffering them to interrupt his serious business: He was eloquent, liberal, crafty, insinuating; a profound master of dissimulation; he spoke of himself with modesty, while he lavished praises on every other person: He stooped even to an acquaintance with the meanest soldier, and constantly adapted himself to the humours, pursuits, and opinions, of those with whom he conversed. Such was his character during the earlier part of his life; but when success had raised him above the necessity of dissimulation, he displayed a hideous train of vices, which his ambition had formerly taught him to conceal.—It was Sylla who recovered the works of Aristotle at the taking of Athens.

SYLLABLE, in grammar, one or more letters pronounced by a single impulse of the voice, forming a complete sound, and constituting a word or a part of a word. No single letter can form a syllable except a vowel. The longest syllable in the English language is the word *strength*.

The most natural way of dividing words into syllables is, to separate all the simple sounds of which any word consists, so as not to divide those letters which are joined close together according to the most accurate pronunciation.

SYLLABUB, a kind of compound drink, most usual in the summer season; ordinarily made of white wine and sugar, into which is squirted new milk with a syringe or wooden cow. Sometimes it is made of canary in lieu of white wine; in which case the sugar is spared, and a little lemon and nutmeg are added in lieu of it. To prepare it the best way, the wine and other ingredients, except the milk, are to be mixed over night, and the milk or cream added in the morning. The proportion is, a pint of wine to three of milk. For

SYLLABUB, *whipt*, to half a pint of white wine or Rhenish is put a pint of cream, with the whites of three eggs. This they season with sugar, and beat with birchen rods, or work with a syringe. The froth is taken off as it rises, and put into a pot; where, after standing to settle two or three hours, it is fit to eat.

SYLLABUS, in matters of literature, denotes a table of contents, or an index of the chief heads of a book or discourse.

SYLLOGISM, in logic, an argument or term of reasoning, consisting of three propositions; the two first of which are called *premises*; the last, the *conclusion*. See LOGIC, Part III. Syllogism
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Sympathy.

SYLVIA, in natural history, a new genus of birds, belonging to the order of passerines, formed by Dr Latham by limiting the motacilla to the wagtail, and arranging the other species, formerly classed under that genus, under the sylvia.

The motacilla he thus describes: The beak is subulated, slender, and somewhat indented at the point. The tongue seems torn at the end, and the tail is long. He thus characterizes the sylvia: The beak is subulated, straight, and small; the mandibles are nearly equal. The nostrils are obovate, and a little depressed. The exterior toe is joined at the under part to the base of the middle one. The tongue is cloven, and the tail is small. He makes 13 species of the motacilla, and 174 species of the sylvia. See MOTACILLA.

SYMBOL, a sign or representation of something moral, by the figures or properties of natural things. Hence symbols are of various kinds; as hieroglyphics, types, enigmas, parables, fables, &c.

SYMMACHUS, a citizen and senator of ancient Rome, and consul in the year 391, has left us ten books of epistles; from which, as well as from other things, we collect, that he was a warm opposer of the Christian religion. He was banished from Rome by Valentinian on some account or other, but afterwards recalled and received into favour by Theodosius. Ammianus Marcellinus speaks of him as a man of great learning and modesty. Scioppius, Pareus, and other learned men, have written notes upon the epistles of Symmachus: we know of no later edition of them than that of Frankfort, 1642, 8vo. Ambrose bishop of Milan wrote against Symmachus, and so did the Christian poet, Prudentius.

SYMMETRY, the just proportion of the several parts of any thing, so as to compose a beautiful whole.

SYMMETRY, in painting. See PAINTING, Part I. Sect. III.

SYMONDSBOROUGH, a remarkable large barrow of Flints, near Wellington in Devonshire, in the northern extremity of Hemyock. The common people have a notion that a king called *Symon* was buried here. The tradition of the country plainly shows that it was the burial-place of some person or persons of eminence.

SYMPATHETIC, something that acts or is acted upon by sympathy. Thus we say, sympathetic diseases, inks, &c.

SYMPATHETIC Inks. See *Sympathetic Ink*.

SYMPATHY, an agreement of affections and inclinations, or a conformity of natural qualities, humours, temperaments, which make two persons delighted and pleased with each other.

SYMPATHY, also denotes the quality of being affected by the affection of another; and may subsist either between different persons or bodies, or between different parts of the same body. It is either similar or dissimilar; similar, when the affection or action in the sympathiser is similar to the affection or action in the sympathant; and dissimilar, when those are different.—Sympathy, too, is often an imitative faculty, sometimes involuntary, frequently without consciousness: thus we yawn when we see others yawn, and are made to laugh by the laughing of another.

Sympathy, according to Dr Jackson*, relates to the operations of the affections of the mind, to the operations of the imagination, and to the affections of the external senses. * Treatise on Sympathy.

I. The passions and affections of the mind produce in the body different sensations and impressions, and, as sympathies of

Sympathy. of consciousness, determine in general the spirits to those parts which labour most, or are most apt to be affected. Thus fear and anger determine to the heart; lust to the eyes, &c.; joy, pity, wonder, and the like, to the head. See *PASSION*, page 14.

The affections of the mind of one person will often work upon the spirits of many. Thus whole companies are sometimes disposed to be sad and melancholy, or merry and jovial, when any one is present much inclined to either of those states of mind; and it has been observed, that old people, who have loved the company of the young, and have been conversant continually with them, have generally lived long. But young people must not conclude from this, that the company and conversation of the grave and old will operate upon their living and sensitive principle, thro' the affections of their mind, and dispose them to be short-lived. On the contrary, by thus improving their understanding, they will be more enabled to fortify their constitution and resist the ravages of youthful indulgence.

It may also be further observed, that those tender sympathetic affections which lay hold of the mind, at the representation of theatrical performances, originate from the same principle, while they are to be considered as the surest test of just execution in the actor, and of the expressive language of the author. Indeed all stage-effect depends on sympathy.

It has been said, that the passions of the mind are occasionally infectious, particularly some of them. Thus *fear* and *shame* are sometimes very suddenly so. We frequently may have occasion to see, that the starting of one will make another ready to start. Again, when one man is out of countenance in company, others will often blush in his behalf. However, the serious passions may surely be so under the controul of reason as to resist infection, whatever may be the case of temporary, muscular, or nervous attraction.

2. Our author is inclined to think, that a connection between the affections and sensations of the female mind and uterus, is very materially concerned in the process of generation, and probably can alone give efficacy to those actions and impressions subservient to conception, through the sympathizing affections of the mind. But this is a subject of which we know so little, that the speculations of even the most distinguished philosophers respecting it have been nothing but the wild ravings of imagination.

With respect to the depravity and force of the imagination in the production of sympathies, they always operate most upon "weak minds and spirits, and therefore most on women, superstitious and fearful persons, sick people, children, and young creatures." "Their effects, however, sometimes fail to appear, because they are encountered and overcome by the mind and spirit before they work any manifest effects."

Such effects are obviated upon the same principle which establishes the prevention of bodily disease: "for in infection and contagion from body to body (as, for example, during the plague), the miasma may be received; but from the strength and good disposition of the body, it is expelled and wrought out before it has had sufficient time to form the disease."

It has been said, and many are of the opinion, that the force of imagination doth often forward the end proposed. Thus, for instance, it has been put as a question, "Whether a man, when he constantly and strongly believes that such a thing shall be (as that such a one will love him, and the like), helps any thing to the effecting the thing desired?" Certainly not in the manner which has been advanced, namely, "by a secret operation on the spirit of another." If he succeeds, it is either because he persevered, or because

his perseverance and earnestness (and not any occult operation) makes him at length be attended to.

There is not a doubt but the force of imagination often gives energy to our actions. It may, however, unless we are much on our guard, easily delude us aside from reason. It has been the tree which has yielded the fruits of superstition in former times, and which has often fed the human mind with the most extravagant notions of sympathy. Sympathies of this kind, such as the power of charms, and the like, are now pretty generally exploded.

3. The five senses, *hearing, tasting, smelling, feeling, and seeing*, are conscious of a sympathetic impression from odious objects. "1. A disagreeable sound will set the teeth on edge, and make all the body shiver. 2. The swallowing of a nauseous medicine will be attended with a shaking of the head and neck. 3. Disagreeable smells produce nearly the same effect, which are less perceived, because there is a remedy at hand by stopping the nose. 4. If you come suddenly out of the sun into the shade, the sense of feeling is disturbed by a chillness or shivering of the whole body. 5. And even sudden darkness produces a propensity to shivering."

There is a very apparent reason why a sympathy should take place between the eyes. Hence their motions are synchronous. It may be said, that custom and habit dispose the eyes to move one and the same way; "for when one eye moveth towards the nose, the other eye moveth from the nose."

Though the eyes are by nature prone to move in concert, custom will, however, destroy this natural concert, and produce the contrary effect. Thus some people can squint when they will. Our author therefore gives this caution to mothers and nurses: "Let them not suffer infants to sit with a candle placed behind them; for both their eyes will be disposed to move outwards, as affecting to see the light of the candle, which may bring on the habit of squinting."

It appears as a quality in the senses of hearing and seeing, "that the instrument of each separate sense has a sympathy and similitude to that which giveth the reflection." Thus it has been observed, "that the eye will sympathize with a crystal glass or water, and the ear with caves and such hollow places as are suited to report echo."

Sympathies have been compared to unisons of sound in music. Unisons of sound produce agreeable sympathetic feelings; the reverse produce disagreeable feelings. "All concords and discords of music are (no doubt) sympathies and antipathies of sound." Moreover, "they are said to work as well by report of sound as by motion."

The most agreeable as well as odious objects operate in a secondary way, in producing those sympathetic impressions and actions which they commonly give rise to. An increased secretion of saliva often takes place at the sight of a favourite dish: and the running of water from a bottle, or otherwise, will sometimes affect individuals of a particular temperament, with an involuntary propensity to void urine.

Many have attempted to account for the remarkable sympathy which takes place between parts of the body seemingly unconnected with each other; but as these attempts are merely conjectures, without any solid principles to rest on, we pass them over as the dreams of ingenious men. It would be fortunate for science, if men would confine themselves to those subjects which can be known, and never draw conclusions till they have established principles.

SYMPHONIA, in botany; a genus of plants, belonging to the class of *monodelphia*, and order of *pentandria*.—There is one pistil. The corolla is globular, and the berry five celled. There is only one species yet discovered, the *globulifera*.

Sympathy.
Symphonia.

Symphony
||
Synagogue.

SYMPHONY, in music, properly denotes a consonance or concert of several sounds agreeable to the ear, whether vocal or instrumental, called also *harmony*. See HARMONY.

SYMPHYSIS, in anatomy, one of the kinds of junctures or articulation of the bones. See ANATOMY, n° 2.

Cutting the SYMPHYSIS of the Pubes. See MIDWIFERY, Part II. Chap. VII.

SYMPHYTUM, COMFREY, in botany: A genus of plants belonging to the class of *pentandria*, and order of *monogynia*; and in the natural system, ranging under the 41st order, *asperifolia*. The limb of the corolla is tubular and ventricose, and the throat is shut with awl-shaped rays. There are three species; the officinale, tuberosum, and orientale.—The officinale is a British plant. The stem is about two feet high, round, branched, green, and rough. The radical leaves are very large and rough; those on the stalk are decurrent, and alternate. The flowers grow on loose spikes, and are either of a yellowish or purple colour. It grows on the banks of rivers, and flowers from May to October.

SYMPLOCE, συμπλοκη, in rhetoric, a figure, where the same word is repeated several times in the beginning and end of a sentence, including the ANAPHORA and EPITROPHE: thus, *Quis legem tulit? Nullus. Quis majorem populi partem suffragiis privavit? Nullus. Quis comitiis præsuit? Idem Nullus.*

SYMPLOCOS, in botany: A genus of plants belonging to the class of *polyadelphia*, and to the order of *polyandria*; and in the natural system ranging under those the order of which has not been determined. The calyx is quinquefid and inferior: the corolla is pentapetalous: the stamina are attached to the tube of the corolla in a fourfold series. Only one species, the martinicensis, is mentioned by Linnæus; but P'Heritier of the Academy of Sciences at Paris had added four more, the cipunima, arechea, tinctoria, and alstonia.

SYMPOSIARCH, in antiquity, the director or manager of an entertainment. This office was sometimes performed by the person at whose charge the entertainment was provided; sometimes by another named by him; and at other times, especially in entertainments provided at the common expence, he was elected by lot, or by the suffrages of the guests.

SYMPTOM, in medicine, any circumstance which indicates the existence, nature, or stage of a disease. Pain, waking, drowsiness, convulsions, suppression of urine, difficulties of breathing and swallowing, coughs, distastes, nausea, thirsts, swoonings, faintings, looseness, costiveness, dryness and blackness of the tongue, are the principal symptoms of diseases. See MEDICINE, n° 41. and 58.

SYMPTOMATICAL, in medicine, is a term often used to denote the difference between the primary and secondary causes in diseases: thus a fever from pain is said to be symptomatical, because it rises from pain only.

SYNÆRESIS, CONTRACTION, in grammar, a figure whereby two syllables are united in one; as *vemens* for *vehemens*.

SYNAGOGUE, among the Jews, was a place where people met to worship God. Authors are not agreed about the time when the Jews first began to have synagogues:—Some will have them as old as the Ceremonial Law, and others fix their beginning to the times after the Babylonish captivity. They erected synagogues not only in towns and cities, but also in the country, especially near rivers, that they might have water for their purifications and ceremonious washings. No synagogue was built in any town, unless there were ten persons of leisure in it; but there might be many in one town, or in one quarter of a town, pro-

vided it was very populous. Jerusalem is said to have contained 480. The chief things belonging to a synagogue were, 1. The ark or chest, made after the model of the ark of the covenant, containing the *Pentateuch*. 2. The pulpit and desk in the middle of the synagogue, in which he that was to read or expound the law stood. 3. The seats or pews for the people. 4. The lamps to give light at evening service, and the feast of dedication. 5. Rooms or apartments for the utensils and alms-chests. The synagogue was governed by a council or assembly, over whom was a president, called *The Ruler of the Synagogue*. These are sometimes called *Chiefs of the Jews*, *The Rulers*, *The Priests* or *Elders*, *The Governors*, *The Overseers*, *The Fathers of the Synagogue*. Their business was to punish the disobedient by censures, by excommunication, or by penalties, such as fines and scourging; to take care of the alms, which are frequently called by the name of righteousness. The chief ruler, or one of the rulers, gave leave to have the law read and expounded, and appointed who should do it. In every synagogue, there were several ministers who had different offices assigned to them. Service was performed three times a day, viz. in the morning, in the afternoon, and at night; at the time of morning sacrifice, evening sacrifice, and after the evening sacrifice on Mondays, Thursdays and Saturdays, there was a more forcible obligation upon the people to attend than upon the other days. There are synagogues at London, Amsterdam, Rotterdam, Avignon, Metz, &c.

SYNALCEPHA, in grammar, a contraction of syllables, performed principally, by suppressing some vowel or diphthong at the end of a word, on account of another vowel or diphthong at the beginning of the next. As, *ill' ego*, for *ille ego*, &c.

Conticuer' omnes intentiqu' ora tenebant. Virg.

It is called by the Latins *collisio*.

SYNARTHROSIS, } See ANATOMY, n° 2.
SYNCHONDROSIS, }

SYNCELLUS, or SINCELLUS, an ancient officer in the family of the patriarchs, and other prelates of the eastern church. The word, in the corrupt Greek, *συγκληρος*, signifies a person who lies in the chamber with another; a *chamber-fellow*, or *chum*. The syncellus was an ecclesiastic, who lived with the patriarch of Constantinople, to be a witness of his conduct; whence it is, that the syncellus was also called the *patriarch's eye*, because his business was to observe and watch. The other prelates had also their syncelli, who were clerks living in the house with them, and even lying in the same chamber, to be witnesses of the purity of their manners. Afterwards the office degenerated into a mere dignity; and there were made syncelli of churches.—At last it became a title of honour, and was bestowed by the emperor on the prelates themselves; whom they called *pontifical syncelli*, and *syncelli Augustales*.

SYNCHRONISM denotes the happening of several things at the same time. See CHRONOLOGY.

SYNCOPE, in music, denotes a striking or beating of time, whereby the distinction of the several times or parts of the measure is interrupted. However, it is more properly used for the connecting the last note of any measure, or bar, with the first of the following measure, so as only to make one note of both. A syncope is sometimes also made in the middle of a measure. Syncope is also used when a note of one part ends or terminates on the middle of a note of the other part. This is otherwise denominated *binding*. It is likewise used for a driving note; that is, when some shorter note at the beginning of a measure, or half measure, is followed by two, three, or more longer notes before another short note occurs,

Syn'apha
||
Syncope-
tion.
Wilson's
Archæologi-
cal Diction-
ary.

Syncope
||
Synognathus.

Synocha
||
Synonymous.

curs, equal to that which occasioned the driving, to make the number even, *i. gr.* when an odd crotchet comes before two or three minims, or an odd quaver before two, three, or more crotchets. In syncopated or driving notes, the hand or foot is taken up, or put down, while the note is sounding.

SYNCOPE, FAINTING; a deep and sudden swooning, wherein the patient contigues without any sensible heat, motion, sense, or respiration, and is seized with a cold sweat over the whole body; all the parts, in the mean time, turning pale and cold, as if he was dead. See **MEDICINE**, n° 98. and 272.

SYNCOPE, in grammar, an elision or retrenchment of a letter or syllable out of the middle of a word, as *caidus* for *calidus*.

SYNDIC, in government and commerce, an officer, in divers countries, intrusted with the affairs of a city or other community, who calls meetings, makes representations and solicitations to the ministry, magistracy, &c. according to the exigency of the case.

SYNECDOCHE, in rhetoric, a kind of trope frequent among orators and poets. See **ORATORY**, n° 56.

SYNECPHONESIS, in grammar, a coalition, whereby two syllables are pronounced as one; being much the same as **SYNALOEPHA** and **SYNÆRESIS**.

SYNEUROSI. See **ANATOMY**, n° 2.

SYNGENESIA, (*συγ* and *γενεσις*, "congeneration"), the name of the 19th class in Linnæus's artificial system; comprehending those plants which have the anthers united into a cylinder. The orders are six: 1. *Polygamia æqualis*. 2. *Polygamia superflua*. 3. *Polygamia frustranea*. 4. *Polygamia necessaria*. 5. *Polygamia segregata*. 6. *Monogamia*. The five first orders contain the compound flowers, and form a class truly natural.

SYNGNATHUS, PIPE-FISH, according to Linnæus, a genus belonging to the class of *amphibia*, and order of *nantes*, but arranged by Gmelin more properly under the class of *pisces*, and order of *branchiostegi*. The head is small; the rostrum somewhat cylindrical, long, and turned up at the point, where the mouth is placed, which is covered with a lid or valve. The gills are covered in the same manner. The body is covered with a strong crust, and has no ventral fins. There are eight species; the tetragonus, typhle, acus, pelagicus, æquoreus, ophidion, barbarus, and hippocampus. Three of these are found in the British seas, *viz.*

1. The *barbarus*, or longer pipe-fish. One described by Sir Robert Sibbald, was two feet in length; that examined by Mr Pennant only 16 inches. The nose was an inch long, compressed sidewise, and the end of the lower mandible turned up; the aperture of the mouth was very small. The irides were red; behind each eye was a deep brown line. The body, in the thickest part, was about equal to a swan's quill, hexangular from the end of the dorsal fin; from thence to the tail, quadrangular. The belly was slightly carinated, and marked along the middle with a dusky line. Under the tail, commencing at the anus, is a fulcus or groove six inches and a half long, covered by two longitudinal valves, which concealed a multitude of young fish. On crushing this part, hundreds may be observed to crawl out.

2. The *acus*, or shorter pipe-fish, is thicker than the former, yet it has been seen of the length of 16 inches. The middle of the body in some is hexangular, in others heptangular. The mouth is formed like that of the former: the irides are yellow: close behind the head are the pectoral fins, which are small and short. On the lower part of the back is one narrow fin; beyond the vent the tail com-

mences, which is long and quadrangular. At the extremity is a fin round and radiated. The body is covered with a strong crust, elegantly divided into small compartments. The belly is white; the other parts are brown.

3. The *ophidion*, or little pipe-fish, seldom exceeds five inches in length, is very slender, and tapers off to a point. It wants both the pectoral and tail fins; is covered with a smooth skin, not with a crust as the two former kinds are. The nose is short, and turns a little up; the eyes are prominent. On the back is one narrow fin. This species is not viviparous: on the belly of the female is a long hollow, to which adhere the eggs, disposed in two or three rows. They are large, and not numerous. The synonym of *serpent* is used in several languages to express these fish: the French call one species *orueul*, from a sort of snake not unlike the blindworm: the Germans call it *meiberschlange*; and the Cornish the *sea-adder*.

The Sea-horse, which was classed by Artedi under the *Syngnathus*, is now, by later ichthyologists, arranged under *TRICHECUS*; which see.

SYNOCHA, and **SYNOCHUS**, in medicine, the names of two species of continued fever. See **MEDICINE**, n° 164.

SYNOD, in astronomy, a conjunction or concurrence of two or more stars or planets, in the same optical place of the heavens.

SYNOD signifies also a meeting or assembly of ecclesiastical persons to consult on matters of religion.

Of these there are four kinds, *viz.* 1. *General*, or *æumenical*, where bishops, &c. meet from all nations. These were first called by the emperors, afterwards by Christian princes; till in later ages the pope usurped to himself the greatest share in this business, and by his legates presided in them when called. 2. *National*, where those of one nation only come together, to determine any point of doctrine or discipline. The first of this sort which we read of in England, was that of Herudford or Hertford, in 673, and the last was that held by cardinal Pole, in 1555. 3. *Provincial*, where those only of one province meet, now called the *convocation*. 4. *Diocesan*, where those of but one diocese meet, to enforce canons made by general councils, or national and provincial *synods*, and to consult and agree upon rules of discipline for themselves. These were not wholly laid aside, till by the act of submission, 25 Hen. VIII. c. 19. it was made unlawful for any *synod* to meet, but by royal authority. See **COUNCIL** and **CONVOCAION**.

SYNODS, *Provincial*, in the Government of the Church of Scotland. See **PRESBYTERIANS**, n° 14.

SYNODALS, or **SYNODIES**, were pecuniary rents (commonly of two shillings), paid to the bishop, or archdeacon, at the time of their Easter visitation, by every parish priest. They were thus called, because usually paid in synods; because anciently bishops used to visit and hold their diocesan synods once.—For the same reason, they are sometimes also denominated *synodalia*; but more usually, *procurations*.

SYNODICAL, something belonging to a synod. Thus, synodical epistles are circular letters written by the synods to the absent prelates and churches; or even those general ones directed to all the faithful, to inform them of what had passed in the synod.

SYNOECIA, in Grecian antiquity, a feast celebrated at Athens in memory of Theseus's having united all the petty communities of Attica into one single commonwealth; the seat whereof was at Athens, where all the assemblies were to be held. This feast was dedicated to Minerva; and, according to the scholiast on Thucydides, it was held in the month *Metagitnion*.

SYNONYMOUS, is applied to a word or term that has the same import or signification with another.

Several

Synovia
||
Syracuse.

Several works have been composed for the express purpose of explaining synonymous words. In 1777 a work was published on the Latin synonyma at Paris by M. Gardin Dumesnil. The abbé Girard published one on the synonymous terms of the French language many years ago. Another was published on the same subject in the year 1785 by the abbé Roubaud. An account of the English synonyma was published by an anonymous author in 1766; which is a close imitation, and in some parts a literal translation, of the abbé Girard's *Synonymes François*. We recollect, too, of seeing some essays of Mrs Piozzi on the same subject.

SYNOVIA, in medicine, a term used by Paracelsus and his school for the nutritious juice proper and peculiar to each part. Thus they talk of the synovia of the joints, of the brain, &c.

SYNTAX, in grammar, the proper construction or due disposition of the words of a language into sentences and phrases. See GRAMMAR and LANGUAGE.

SYNTHESIS, in logic, denotes a branch of method, opposite to analysis.

In the synthesis or synthetic method, we pursue the truth by reasons drawn from principles before established or assumed, and propositions formerly proved; thus proceeding by a regular chain, till we come to the conclusion. Such is the method in Euclid's Elements, and most demonstrations of the ancient mathematicians, which proceed from definitions and axioms, to prove propositions, &c. and from these propositions proved to prove others. This method we also call *composition*, in opposition to *analysis* or *resolution*. See ANALYSIS.

SYPHILIS. See MEDICINE, n° 350.

SYPHON. See HYDROSTATICS, n° 25, 26. Some uncommon phenomena in nature may be accounted for upon the principles of the syphon; as, for instance, that of reciprocating springs. See PNEUMATICS, n° 273.

1
At what
time built.

2
Govern-
ment origi-
nally mo-
narchical.

3
Soon be-
comes de-
mocratical.

4
Gelon sei-
zes on the
sovereignty.

SYRACUSE, once a celebrated city of Sicily, and the capital of the island. It was built, according to Thucydides and Strabo, by Archias, one of the Heraclidae, who came from Corinthus into Sicily in the second year of the 11th Olympiad, deriving its name from a neighbouring marsh named *Syraco*. What form of government first prevailed in the city is not known. Many have supposed it originally to have been governed by kings: but if this was the case, the monarchical government must have continued only for a very short time; since Aristotle, Diodorus Siculus, and Justin, mention it as being very early subject to a democracy. The history, however, is obscure and unimportant till the time of Gelon, when it first began to make a conspicuous figure.

Gelon was born in the city of Gela in Sicily, of the family of Telines, who had been created priest of the infernal gods. He signalized himself in a war carried on by Hippocrates tyrant of Gela against the Syracusians, whom he defeated in a pitched battle, and had well nigh taken their city afterwards. Having thus become very powerful among his countrymen, he soon found means to seize on the sovereignty for himself. In a short time, having put himself at the head of some Syracusian exiles, he marched towards that place, where he was received with loud acclamations by the faction to which they belonged; and by their means obtained possession of the city.

5
Takes seve-
ral cities,
and re-
moves the
inhabitants
to Syracuse.

Gelon, in order to people the capital of his new dominions, first demolished the neighbouring city of Camarina, and transplanted the inhabitants to Syracuse. Soon after, entering into a war with the Megareans, he defeated them, took and rased their cities, and in like manner transplanted the people. Syracuse thus became very powerful, and full of inhabitants; and the friendship of Gelon was courted both

by Athens and Lacedæmon at the time of the Persian invasion. His assistance, however, was afterwards rejected, as he insisted upon being made commander in chief either of the fleet or the army. In the mean time the Carthaginians had entered into a treaty with the Persians, by which it was agreed, that the former should attack those of the Greek name in Sicily and Italy, in order to divert them from assisting one another. Sicily was accordingly invaded by the Carthaginians with a vast army; but they were utterly overthrown by Gelon, as is related under the article CARTHAGE, n° 7—9. After this victory, the people out of gratitude obliged him to take upon himself the title of king; which till that time he had refused. A decree also passed without opposition, by which the crown was settled on his two brothers Hiero and Thrasybulus after his death.

The new king, instead of keeping his subjects in greater awe, studied the more to make them happy as he found his power increased; and, according to Diodorus Siculus, was the first man who became more virtuous by being raised to a throne. He was particularly famous for his honesty, truth, and sincerity; is said never to have wronged the meanest of his subjects, nor ever to have promised a thing which he did not perform.

Gelon died in the year 471 B. C. after having reigned three or four years; and was succeeded by his brother Hiero, whose character is differently drawn by different historians. He was twice engaged in a war with the Agrigentines, and drove from their habitations the people of Catana and Naxos, settling in their room a colony of Syracusians and Peloponnesians. He is highly celebrated in the odes of Pindar; and it is certain that his court was the resort of men of wit and learning, to whom he behaved in the most courteous manner and with the greatest liberality.

In 459 B. C. Hiero was succeeded by Thrasybulus; who proving a tyrant, was in ten months driven out, and a popular government restored; which continued for the space of 55 years. Several persons continued for some time to aspire at the sovereign power; and to rid themselves of these aspiring geniuses, the inhabitants made a law not unlike that of the ostracism at Athens. By this law they were to write on a leaf the names of those whom they supposed to be powerful enough to aspire at the crown; and when the leaves were counted, he who had the most suffrages against him was, without further inquiry, banished for five years. This method of weakening the interests of the overgrown citizens was called *petalism*, from the Greek word *πεταλον*, signifying a leaf; but being found to be productive of great inconveniences, by driving out of the country all those who were most capable of governing the commonwealth, the law was repealed soon after it had been enacted.

About this time the Syracusians entered into a war with the Siculi, which terminated in the total subjection of the latter; after which Syracuse became so powerful, that it in a manner gave law to the whole island. The Greek cities indeed enjoyed a perfect liberty; but they all acknowledged Syracuse as their metropolis; by degrees, however, the latter began to assume such an authority over them as was totally inconsistent with liberty; and this occasioned many wars, which involved them in much distress and danger. They began with the Leontines, whose territory they laid waste, and reduced their city to great straits. Leontini was an Athenian colony; and this furnished the Athenians, who had already meditated the conquest of Sicily, with a pretence to attack the Syracusians with their whole force. Under colour of assisting their countrymen, therefore, they sent a fleet of 250 sail to Sicily: but the Leontines, sensible that

Syracuse.

6
Defeats the
Carthagi-
nians, and
takes the
title of
king.

7
His excel-
lent reign.

8
Gelon dies,
and is suc-
ceeded by
Hiero.

9
Thrasybu-
lus, a ty-
rant.

10
Popular
gov-
ernment re-
stored.

11
Petalism in-
troduced,
but soon
after abo-
lished.

12
The Siculi
subdued.

13
Syracusians
become
haughty.

14
Invaded by
the Athe-
nians with-
out success.

¹⁵ ^{Syracuse.} that their pretended allies aimed at nothing less than the conquest of the whole island, concluded a peace with Syracuse; and the disappointed Athenians vented their rage upon those who had advised and conducted the expedition.

¹⁶ ^{A new invasion.} In 416 B. C. a dispute happening between the inhabitants of Egesta and Selinus concerning some lands which the latter had seized, the Egestines applied for assistance to Agrigentum, Syracuse, and even to Carthage. But as none of these states chose to interest themselves in their quarrel, they applied at last to the Athenians, who joyfully accepted of the opportunity of again interfering in the affairs of Sicily. Though the Egestines were but an inconsiderable people, they had engaged to pay all the troops that should be employed in the war; but this appearing doubtful to the Athenians, they sent ambassadors to inquire into the state of the island in general, and particularly that of Egesta. The Egestines imposed on these ambassadors by producing a great number of gold and silver vessels which they had borrowed for the purpose; so that the populace of Athens, dreaming of nothing but conquests to be made without any expence, became obstinately bent on the war. Nicias, a man of great influence at Athens, attempted to show, that as Athens was then engaged in a dangerous war with Sparta, it was impossible to spare a force sufficient to reduce the island; but the contrary opinion being espoused by Alcibiades, at that time the most eloquent speaker in Athens, Nicias was overruled, and obliged to engage in the expedition. The force he required was only 5000 land forces and 100 galleys, with which, however inadequate to the purpose it may seem, the Athenians were so sure of success, that the officers, before they set sail, had a conference with the senate concerning the disposal of the Sicilians. In this conference it was agreed, that the Selinuntines and Syracusians their supposed allies should be carried off and sold for slaves, and the rest obliged to pay an annual tribute and live according to the Athenian laws.

¹⁷ ^{Ill-grounded confidence of the Athenians.} With these sanguine expectations the Athenian forces embarked to the number of 7000; for such was their eagerness for the expedition, that 2000 more enlisted themselves than Nicias had required. They first sailed to the island of Egina, and from thence to Corcyra, where they had appointed the place of rendezvous for their allies and the transports. On their arrival they set sail again, and landed on the coast of Italy, with a view to engage some of the Italian cities in their quarrel; but finding this impossible, they sent some ships to cruise off the coast of Sicily, in order to find out a proper place for landing, and at the same time to know what treasure the Egestines could contribute towards carrying on the war, which had been undertaken for their sake. These, on their return, acquainted the generals, that the Egestines had imposed on them, and were a poor indigent people, who had only 30 talents in the treasury. On this information a council of war was called, in which Nicias gave it as his opinion that they should sail to Selinus, which had been the first occasion of this expedition; and then, if the Egestines performed their promise, and supplied the army with a month's pay, to oblige the Selinuntines and Egestines to come to an agreement, and then return to Athens without engaging in such an expensive war. Alcibiades, however, again opposed Nicias; thinking it highly dishonourable to return home without doing any thing, after having been at the expence of fitting out an armament. He therefore urged, that they should solicit the cities of Sicily to enter into a confederacy against the Syracusians and Selinuntines; and, in case they found them disposed to come into their measures, to attack either Syracuse or Selinus. Another of the Athenian generals was for laying siege immediately to Syracuse; but the opinion of Alcibiades prevailing, they

set sail for Sicily. Having accordingly landed in that island, they reduced several places; but Alcibiades in the mean time being recalled, Nicias and Lamachus were left to conduct the war as they best could. At first they were successful, possessing themselves of a strong post, and put the Syracusians to flight; soon after which they received considerable supplies both of men, money, and provisions, from Athens, as well as from their Sicilian allies. The Syracusians also received assistance from the Lacedæmonians under the command of an experienced officer named Gylippus. Before these arrived, the Athenians had possessed themselves of an important post named *Epipolæ*, which being a very steep hill, stood without the city and commanded it. Immediately after this the city was invested in form. The inhabitants made frequent and vigorous sallies; but were always repulsed with loss. In one of these sallies Lamachus was slain; and thus Nicias became sole commander. He then caused the canals to be cut by which water was conveyed into the city; upon which the Syracusians began to think of capitulating. From this, however, they were soon after prevented by the arrival of Gylippus with the Spartan auxiliaries. On this they prepared for making vigorous sallies, in order to facilitate the entrance of Gylippus. While they were making these preparations, Gylippus himself appeared at the head of 3000 foot and 200 horse. Making directly for *Epipolæ*, where Nicias had fortified himself in a castle named *Labdalon*, he drew up his small army under the walls; and sent an herald to Nicias, letting him know that he would allow him only five days to leave Sicily. To this message Nicias returned no answer; but Gylippus soon after attacked the fort, carried it by storm, and put to the sword all the Athenians that were in it. This opened for him a way into the city, where he was received with loud acclamations.

The fortune of the war was again changed. The Athenians gained an advantage by land, but were next day defeated with considerable loss. The Syracusians received fresh supplies from Corinth, and the Athenians from their own country. Many engagements both by sea and land took place, in which the success was ultimately in favour of the Syracusians. At last the Athenian affairs were totally ruined by the loss of a sea-fight, in which 60 of their ships were taken or destroyed, and the rest left quite unserviceable. In this desperate situation it was determined to abandon their ships, and retire that very night to the city of their confederates. The Syracusan commander, suspecting that this would be the case, ordered all his forces to be in readiness to prevent them from effecting their purpose. But as the people were then in the height of their rejoicing for the late victory, they refused to take up arms again until they had rested for some days. On this Hermocrates the general sent to the Athenian camp some horsemen, who were to pass for friends, and to advise Nicias not to quit his camp, which was well fortified, since the Syracusians lay in ambush for him, and had seized on all the passes leading to the cities of their allies. To this false advice Nicias gave too easy credit, and did not march out till the third day, when his antagonist Hermocrates had prevailed upon his forces to march out. The Athenians and their allies also marched out to the number of no less than 40,000; but finding themselves shut up on all sides, and being obliged to fight their way through every outlet, they soon sunk into the deepest despair. Nicias did his utmost to encourage them; and at last succeeded so far that they marched out in two bodies, both drawn up in proper order. The vanguard led by Nicias continued to keep together, and advanced in good order; but half the rear, commanded by Demosthenes, lost their way in the night, and were obliged to surrender. Nicias

^{Syracuse.} Reduce several places.

²⁰ Defeat the Syracusians, and possess themselves of a strong post.

²¹ Syracuse invested.

²² Gylippus arrives with some Spartans to the relief of Syracuse!

²³ Takes a fort, and enters the city.

²⁴ Athenians totally defeated at sea.

²⁵ Outwitted by the Syracusan general.

²⁶ Harassed in their retreat.

²⁷ Part of the army surrenders.

Syracuse.

28
The rest
defeated
with great
slaughter.

29
The re-
mainder
surrender,
and are
cruelly u-
sed.

30
New inva-
sion by the
Carthagi-
nians.

31
Rise of
Dionysius.

cias being informed of this misfortune, offered to pay the whole expence of the war, provided he was allowed to march off with his men. But this being rejected, he set out, tho' galled all the way by showers of darts from his enemies. Arriving at a river called *Asmarus*, they rushed into it without any order; in which confusion the Syracusan cavalry attacked them so desperately, that 18,000 perished, and the river for many miles was dyed with their blood. On this occasion the Athenians were so pressed with thirst, that, unmindful of their danger, they drank the waters of the river all bloody as they were, which gave their enemies the better opportunity of slaughtering them without resistance. The remainder surrendered, on the single condition of having their lives saved; but the terms were shamefully broke by the Syracusians. The generals were first ignominiously whipt, and then put to death: the common soldiers were thrust down into quarries, where they were allowed only two small measures of flour and one of water a-day; and where, being crowded upon one another, they suffered inexpressible miseries for many months. Most of them perished by this cruel treatment, and the few who survived were sold for slaves.

The war was scarce ended, when a new and formidable invasion by the Carthaginians took place; but the event of that expedition was as unfortunate to the Carthaginians as the former had been, of which a particular account is given under the article *CARTHAGE*, n° 12. *et seq.*

In the mean time, however, a considerable revolution had happened in Syracuse. The city of Agrigentum had been taken by the Carthaginians, and of the few inhabitants who escaped, some fled to Syracuse, where they accused the Syracusan commanders of having betrayed the city into the hands of the enemy. Dionysius, a man of great valour and address, but who had become very obnoxious to the populace, took this opportunity of attempting to retrieve his credit. He therefore supported the accusations brought against his countrymen by the Agrigentines, and even impeached the magistrates as having a secret intelligence with the enemy, and attempting to introduce an oligarchy. As his speech was entirely levelled against the more wealthy citizens, it was very agreeable to the lower class: the commanders were instantly degraded; and others, among whom was Dionysius, were appointed. Having once gained this point, he began to consider how he might get all his colleagues turned out. For this purpose he never joined in any council of war with the other commanders, nor imparted to them his resolutions, giving out that he could not trust them, and that they had more regard for their own interest than the welfare of their country. But while he was proceeding in this manner, the more prudent part of the citizens, perceiving what he aimed at, complained of him to the senate and magistrates, and fined him as a disturber of the public peace. According to the laws, the fine was to be paid before he could speak in public, and the circumstances of Dionysius did not allow him to discharge it. In this dilemma he was assisted by Philistus the historian, a man of great wealth, who not only paid this fine for him, but encouraged him to speak his mind freely, as it became a zealous citizen to do, promising to pay all the fines that should be laid upon him.

Being extricated out of this difficulty, Dionysius next proceeded to inveigh, with all the eloquence he was master of, against those who by means of their power or interest were able to oppose his designs, and by degrees brought them into discredit. His next scheme was to get those exiles recalled whom the nobility had banished at different times; as thinking that they would support him with all their power, as well out of gratitude as out of hatred to the

opposite party. Having gained this point also, he next found means to ingratiate himself with the soldiery to such a degree, that, under pretence of taking proper measures for resisting the Carthaginians, he was chosen commander in chief, with absolute and unlimited power. This was no sooner done, than, pretending that his life was in danger, he chose out 1000 men for his guard, whom he attached to his interest by great promises. As no person durst now oppose him, he possessed himself of the citadel, where all the arms and provisions were kept; after which he publicly took the title of king of Syracuse in the year 404 B. C.

The Syracusians did not tamely submit to their new master: but Dionysius managed matters so well, that their frequent revolts answered no other purpose than more certainly to entail slavery on themselves; and he was allowed to possess the throne without much opposition till his death, which happened in the year 366 B. C.

On the death of Dionysius, he was succeeded by his son, Dionysius II. called also *Dionysius*. He was naturally of a mild and peaceable temper, averse from cruelty, and inclined to learning; but his father, to whom all merit, even in his own children, gave umbrage, stifled as far as possible his good qualities by a mean and obscure education. He no sooner ascended the throne, than Dion, brother to Aristomache the other wife of Dionysius the Elder, undertook to correct the faults of his education, and to inspire him with thoughts suitable to the high station in which he was placed. For this purpose he sent for the philosopher Plato, under whose care he immediately put the young king. This instantly produced a reformation on Dionysius; but the courtiers, dreading the effects of the philosopher's instructions, prevailed on him to banish Dion, and to keep Plato himself in a kind of imprisonment in the citadel. At last, however, he set him at liberty; upon which Plato returned to his own country.

Dion, in the mean time, visited several of the Grecian cities, and at last took up his residence in Athens; but the honours which were everywhere paid him, raised such jealousies in the breast of the tyrant, that he stopped his revenue, and caused it to be paid into his own treasury. In a short time Dionysius again sent for Plato; but finding it impossible to dissolve the friendship between him and Dion, disgraced, and placed him in a very dangerous situation, in the midst of assassins who hated him. Not daring, however, to offer him any violence, he allowed him soon after to depart; revenging himself on Dion, whose estate he sold, and gave his wife Arete in marriage to Timocrates one of his own flatterers.

Dion now resolved to revenge himself on the tyrant for the many injuries he had sustained, and at once to deliver his country from the oppression under which it groaned. He began with raising foreign troops privately, by proper agents, for the better execution of his design. Many Syracusians of distinction entered into his scheme, and gave him intelligence of what passed in the city; but of the exiles, of whom there were upwards of 1000 dispersed up and down Greece, only 25 joined him; so much were they awed by the dread of the tyrant. The troops were assembled at the island of Zacynthus, in number only about 800; but who had all been tried on many occasions, were well disciplined, and capable of animating by their example the forces which Dion hoped to find in Sicily. When they were about to sail, Dion acquainted them with his design, the boldness of which at first occasioned no small consternation among them; but Dion soon removed their fears, by telling them that he did not lead them as soldiers, but as officers, to put them at the head of the Syracusians and all the people of Sicily, who were ready to receive them with open arms.

³⁹ ^{Is in great danger.} ⁴⁰ ^{Eners Syracuse with- out opposi- tion.} ⁴¹ ^{Dionysius arrives, but is totally defeated.} ⁴² ^{Ingratitude of the Syracu- sians to Dion.} ⁴³ ^{He is obli- ged to leave the city.} ⁴⁴ ^{A new ad- vantage gained over the Diony- sians.}

arms. Having then embarked in two small trading vessels, they arrived in 12 days at Cape Pachynum near Syracuse. Their pilot advised them to land immediately, lest they should be overtaken by a violent storm, which he perceived was approaching; but Dion, judging it improper to land so near the enemy, commanded him to put to sea again, and double the Cape. — This was no sooner done than the storm came on; and the two vessels were driven on the coast of Africa, where they were in great danger of being lost. At last they arrived at the port of Minoa, not far from Agrigentum. Here they received intelligence that Dionysius had set sail for Italy, attended by a fleet of 80 galleys. On this Dion resolved to take advantage of the tyrant's absence; and immediately set sail for Syracuse. On his march he prevailed upon the inhabitants of Agrigentum, Gela, Camarina, and other cities, to join him. As soon as he entered the territories of Syracuse, multitudes flocked to him; and as nobody appeared to oppose him, he boldly entered the city, where he quickly found himself at the head of 50,000 men. As soon as he had landed in Sicily, Timocrates, to whom his wife Arete had been given by Dionysius, and to whom the care of the city had been left, dispatched a courier to let the tyrant know the danger in which he was. The messenger, when almost at his journey's end, found himself so much oppressed by fatigue, that he could not help lying down on the ground to take some rest. In the mean time, a wolf, smelling some meat which he had in his wallet, came to the place, and carried off the bag in which was the meat, together with the dispatches. By this means Dionysius was prevented from receiving a timely account of Dion's arrival; so that when he entered the citadel by sea, seven days after Dion's arrival, he found his affairs in a desperate situation. Upon this he had recourse to artifice; and having amused the Syracusians by a feigned negotiation, until he observed that they kept a negligent guard, he attacked them all at once with such fury, that he had almost taken the city. But Dion encouraged the soldiers by his example so much, that he at last obtained a complete victory; for which they presented him with a crown of gold.

It was not long, however, before the ungrateful Syracusians began to think of conferring quite different rewards on their benefactor. Dionysius had the address to render him suspected by the multitude; at the same time that Heraclides, an excellent officer, but a secret enemy to Dion, did all that lay in his power to sink his credit. In a short time Dionysius was obliged to fly into Italy; after which Heraclides, in order to ingratiate himself with the populace, proposed a new division of lands; insinuating, that they could never enjoy perfect liberty as long as there was so much inequality in wealth and power among the citizens. This scheme was opposed by Dion, in consequence of which a general combination was formed against him; and he was deserted by all excepting the foreign troops whom he had brought with him into the island. The Syracusians solicited even these to abandon the cause of their general: but their offers were rejected with disdain; and Dion, with his faithful adherents, getting clear of the tumultuous and riotous populace, took the road to Leontini. The rabble pursued him, but were soon driven back: and Dion resided for some time at Leontini, where he was received with all the respect due to his character.

In the mean time, the citadel still continued in the hands of the adherents of Dionysius. Being blocked up on all sides, they were reduced to great straits, and were actually making proposals of capitulation, when Nypsius, an experienced general, and greatly attached to Dionysius, appeared with a numerous squadron of galleys, and a large fleet of

transports laden with provisions. The general landed his men, and got them into the citadel; but almost all his galleys and ships laden with corn were sunk or taken. This victory proved the ruin of the Syracusians; for, giving themselves up to feasting and debauchery, the enemy sallied out in the night-time from the citadel, and massacred the citizens without mercy. Being thus made sensible of the error they had committed, an embassy was sent to Dion, entreating him to return and save the city a second time. To this he agreed without hesitation, and instantly set out on his march; but in the mean time, as the soldiers of Dionysius, satiated with slaughter, had retired into their fortrefs, the ungrateful Syracusians began to repent of their having sent an embassy to Dion. The chief commanders, therefore, sent messengers to stop his march; but as some of his friends sent deputies to him at the same time, desiring him to pay no regard to the former message, he proceeded on his journey. The infatuated multitude seized the gates in order to dispute his entrance; but they paid dear for their frenzy. The Dionysians again sallied out upon them, and made such slaughter, that one would have thought they had left none alive in the city. As the troops of the tyrant well knew that Dion was hastening to the relief of the city, they used their utmost endeavours to destroy it entirely before his arrival; for, after they had murdered all the inhabitants they could find, they set fire to the houses, by which great numbers perished. During this confusion Dion unexpectedly arrived; and having briskly attacked the enemy, at last defeated them with great slaughter, driving the remainder into the citadel. During the rest of the night, instead of refreshing themselves after their fatigues, they assisted in extinguishing the fire; which was not done without great danger and difficulty. The citadel soon after surrendered; and Dion allowed Apollocrates the tyrant's son, who commanded there, to retire with five galleys to his father. As soon as Dion entered the citadel, he was met by his sister and wife Arete, whom he received with affection, notwithstanding her having lived so long with Timocrates. He then left the Syracusians in possession of the citadel, rewarded his followers, dismissed his guards, and continued to live like a private citizen.

As soon as Dion had got possession of the city, Heraclides had submitted to him, and been received into favour; but as his seditious and turbulent behaviour still continued, Dion at last gave orders to put him to death. This action, however necessary, so affected the mind of Dion, that he became melancholy; and ever after imagined himself haunted by a frightful spectre, resembling a woman of gigantic stature, with the haggard looks and air of a fury. In a short time after he lost his life, through the base treachery of Calippus, or Gylippus, who pretended to be his intimate friend, and who immediately after caused his wife and sister to be carried to prison.

Calippus having thus removed Dion, soon made himself master of Syracuse, where he committed all manner of cruelties; but was driven out, and forced to fly to Rhegium, where he was murdered with the same dagger which had killed Dion. In 350 B. C. Dionysius again made himself master of Syracuse; and being exasperated by his past misfortunes, tyrannized worse than ever. The Syracusians first had recourse to Ictas tyrant of Leontini; but as the Carthaginians took this opportunity to invade them with a powerful fleet and army, they were obliged to apply to the Corinthians. By them Timoleon, a celebrated commander, was sent to the assistance of the Syracusians, whom he found in a very distressed situation; Ictas being master of the city, the Carthaginians of the harbour, and Dionysius of the citadel. As all parties were equally the enemies of Dionysius,

Syracuse. ⁵⁰ **Surrenders** to Timoleon, and keeps a school at Corinth. ⁵¹ **Cowardice** of the Carthaginians. ⁵² **Citadel** of Syracuse and other forts demolished by Timoleon. ⁵³ **He repeoples** the city. ⁵⁴ **Dies, and is** honoured as a god. ⁵⁵ **Syracuse** again falls under the power of tyrants. ⁵⁶ **Pyrrhus** king of Epirus invited into Sicily. ⁵⁷ **Conquers** a great part of the island.

fius, he found it impossible to hold out, and therefore surrendered himself to Timoleon, by whom he was sent to Corinth; where at last he was reduced to the necessity of teaching a school for his support.

After the expulsion of the tyrant, Timoleon withdrew to Catana, leaving only 400 Corinthians, under the command of an experienced officer named Leon, to guard the citadel. These were immediately besieged by Ictas and the Carthaginians, but Timoleon found means to relieve them in spite of all opposition; and having dispersed emissaries through the army of Mago the Carthaginian general, exhorting the mercenary Greeks to forsake him, he was so much intimidated, that in spite of all the remonstrances Ictas could make, he set sail for Africa, leaving his colleague to carry on the war in the best manner he could.

The day after the departure of Mago, Timoleon assaulted the city so briskly, that the troops of Ictas were driven from the walls, and the Corinthians became masters of the place. Timoleon, by sound of trumpet, invited the inhabitants to come and assist in demolishing the citadel and other castles, which he called the *nests of tyrants* ; after which he caused edifices to be erected in the place where the citadel had stood, for the administration of justice. He found the city in a most miserable situation: for many having perished in the wars and seditions, and others having fled to avoid the oppression of tyrants, Syracuse, once so wealthy and populous, was now become almost a desert; inasmuch that the horses were fed on the grass which grew on the market-place. Timoleon supplied the city with inhabitants from Corinth and other cities of Greece, at the same time that great multitudes from Italy and the other parts of Sicily resorted thither. Timoleon distributed the lands among them *gratis* ; but sold the houses, and with the money arising from the sale established a fund for the support of the poor. Having thus restored Syracuse, he in like manner delivered all the Greek cities of Sicily from the tyrants who had taken possession of them, all of whom he put to death. After this he resigned his authority, and led a retired life, honoured in the highest degree by the Syracusians, and by all the cities in Sicily. After his death he was honoured as a god; the expence of his funeral was defrayed by the public; sports, with horse-races and gymnastic exercises, were held annually on the day of his death; and it was decreed, that whenever the Syracusians were at war with the barbarians, they should send to Corinth for a general.

For 20 years the Syracusians enjoyed the fruits of Timoleon's victories; but new disturbances arising, in a short time another tyrant started up, who exceeded all that had gone before him in cruelty and other vices. This was the celebrated Agathocles, of whose exploits against the Carthaginians a full account is given under the article *CARTHAGE* , n° 33—53. He was poisoned by one Mœnon in the year 289 B. C. after having reigned 28 years, and lived 95.—A succession of tyrants followed, till at last the city, being held by two rivals, Tœnion and Sosistratus, who made war within the very walls, Pyrrhus king of Epirus was invited into Sicily, in order to put an end to these distractions. He willingly complied with the invitation; and was everywhere received with loud acclamations, as the deliverer not only of Syracuse, but of all Sicily. As he had a fine army of 30,000 foot and 5000 horse, with a fleet of 200 sail, he drove the Carthaginians from place to place, till he left them only the two strong posts of Eryx and Lilybæum. The former of these he took by assault, and was himself the first man who mounted the walls, after having killed a great number of Africans with his own hand. The Mamertines likewise, who had conquered a considerable part of the island, were everywhere defeated and driven out, till at last they were

shut up in the city of Messina. The Carthaginians, alarmed at the rapidity of his conquests, sent ambassadors with proposals of peace upon very advantageous terms; but Pyrrhus, puffed up with the expectation of reducing the whole island, refused to hearken to any terms unless they would instantly abandon it. So firm was he in the belief of this, that he caused his son take upon him the title of *king of Sicily* ; but in the mean time, having displeased the Sicilians by his arbitrary behaviour, they deserted from him in such numbers that he was glad to set out for Italy, for which retreat the embassies he received from the Samnites, Tarentines, and other Italians, furnished him with an honourable pretext. He embarked in the ships which he had brought with him from Italy; but was met at sea by the Carthaginians, who sunk 70 of his vessels, and dispersed or took the rest; so that he saved himself in Italy only with 12 vessels, the poor remains of a fleet of 200 sail. No sooner were the Mamertines apprised of his departure, than they dispatched a body of 18,000 men to harass him after his landing. These, having passed the straits before him, posted themselves in the road which Pyrrhus must take in marching by land to Tarentum; and concealing themselves among woods and rocks, attacked him unexpectedly, and with great resolution. But Pyrrhus behaved on this occasion with his usual bravery. The attack being made on his rear, he hastened thither, and made a dreadful slaughter of the enemy, till a wound on his head obliged him to retire. As he was supposed to be disabled by this wound, a proud Mamertine, of an extraordinary size, and shining in bright armour, advanced, and with a loud voice challenged the king of Epirus, if he was yet alive, to a single combat. Pyrrhus immediately turned about, and making a dreadful appearance by reason of the blood which ran down his face, flew at this new champion, on whose head he discharged such a furious blow, that he cleft his body asunder; one half falling to the right, and the other to the left. This incredible feat, which has since been ascribed to other warriors, perhaps with as much truth as to Pyrrhus, so much intimidated the Mamertines, that they allowed his troops to continue their march unmolested.

After the departure of Pyrrhus, Hiero the son of Hiero-chicles, a descendant of Gelon the first king of Syracuse, was chosen general of the forces, along with another named *Artemidorus* . The two generals had nothing more at heart than to put an end to the confusion and disorder which reigned in the city; for which reason they entered it at the head of their forces. On this occasion Hiero discovered extraordinary talents for government. By mere dint of insinuation and address, without shedding blood, or hurting a single citizen, he calmed the minds of the people; reconciled the factions; and so gained the affections of all, that he was invested with the whole civil as well as military power in the state. Soon after this, he married the daughter of one of the first citizens; and having distinguished himself by his exploits against the Mamertines, was unanimously elected king of Syracuse, in the year 265 B. C.

Some time after Hiero's accession to the throne, he again defeated the Mamertines, and reduced them to such straits, that they were obliged to call in the Romans to their assistance. The consequences of this have been fully related under the articles *ROME* and *CARTHAGE* . Hiero, who had allied himself with the Carthaginians, being himself defeated by the Romans, and finding his allies unable to protect him against the power of that republic, concluded an alliance with them; and continued faithful to them even in the time of the second Punic war, when they were in the greatest distress. In his reign flourished the celebrated mathematician Archimedes, whose genius he employed in fortifying the

Syracuse.

⁵⁸ Behaves in a haughty manner, and is obliged to return into Italy.

⁵⁹ Harassed by the Mamertines.

⁶⁰ Astonishing exploit of Pyrrhus.

⁶¹ Hiero chosen general of the Syracusan forces.

⁶² Is elected king of Syracuse.

⁶³ Lives in strict friendship with the Romans.

Syracuse. the city of Syracuse, by innumerable machines, in such a manner as rendered it absolutely impregnable to every method of attack known at that time.

64 Hieronymus allies with the Carthaginians.

* See Carthage, n° 123.
65 Syracuse invested.

66 Great force of the Romans by sea and land.

67 Machine invented by Marcellus.

68 Destroyed by Archimedes.

69 Incredible effects of the machines of Archimedes.

Hiero died about 211 B. C. and was succeeded by his grandson Hieronymus: but he imprudently forsook the counsels of his grandfather, and entered into an alliance with the Carthaginians. Soon after this he was murdered, in consequence of his tyranny and cruelty, and the greatest disorders took place in the city; which Hannibal, though then in Italy, found means to foment, in hopes of keeping the Syracusians in his interest. This indeed he effected; but as his own affairs in Italy began to decline*, he could not prevent Marcellus from landing in Sicily with a formidable army, which the Sicilians could by no means resist. Syracuse was soon invested; but the machines invented by Archimedes baffled all attempts to take it by assault. It was 22 miles in compass, and consisted properly of five cities in one, viz. Ortygia, Acradina, Tyche, Neapolis, and Epipolæ.—Ortygia was a small island very near the continent, and might be called the *citadel of Syracuse*, being joined to Acradina by a bridge. The immense preparations which the consul had made for taking the city by storm, could not have failed to accomplish his purpose, had the place been otherwise defended than by the contrivance of Archimedes. The Roman fleet consisted of 60 quinqueremes, besides a far greater number of other ships. The decks were covered with soldiers armed with darts, slings, and bows, to drive the besieged from the ramparts, which on the side of Acradina were washed by the sea, and to facilitate the approach to the walls. But a machine of Marcellus's own invention was what he chiefly depended on. He had fastened together sidewise eight galleys of different lengths, which made but one large body, and were rowed only by the oars of the outermost galleys. These eight galleys thus joined, served only as a basis for a machine, which was raised up higher than the highest towers of the walls, and had at the top a platform guarded with parapets in front and on each side. This machine was called a *sambuca*, from its resemblance to a musical instrument of that name, not unlike an harp. The consul's design was to bring his *sambuca* to the foot of the walls of Acradina; but, while it was at a considerable distance (and it advanced very slow, being moved only by two ranks of rowers), Archimedes discharged from one of his engines a vast stone, weighing, according to Plutarch's account, 1250 pounds, then a second, and immediately after a third; all which, falling upon the *sambuca* with a dreadful noise, broke its supports, and gave the galleys upon which it stood such a violent shock that they parted, and the machine which Marcellus had raised upon them at a vast trouble and expence was battered to pieces. At the same time, several other machines, which were not visible without the walls, and consequently did not lessen the confidence of the Romans in the assault, played incessantly upon their ships, and overwhelmed them with showers of stones, rafters, and beams pointed with iron; insomuch that Marcellus, being at a loss what to do, retired with all possible haste, and sent orders to his land-forces to do the same; for the attack on the land-side was attended with no better success, the ranks being broken and thrown into the utmost confusion by the stones and darts, which flew with such noise, force, and rapidity, that they struck the Romans with terror, and dashed all to pieces before them.

Marcellus, surprised, though not discouraged, at this artificial storm, which he did not expect, held a council of war, in which it was resolved, the next day before sun-rise, to come up close under the wall, and keep there. They were in hopes by this means to secure themselves against the terrible storm of stones and darts which fell on the ships

when at a distance. But Archimedes had prepared engines which were adapted to all distances. When the Romans therefore had brought their ships close under the wall, and thought themselves well covered, they were unexpectedly overwhelmed with a new shower of darts and stones, which fell perpendicularly on their heads, and obliged them to retire with great precipitation. But they were no sooner got at some distance, than a new shower of darts overtook them, which made a dreadful havock of the men, while stones of an immense weight, discharged from other machines, either disabled or broke in pieces most of their galleys. This loss they sustained, without being able to revenge it in the least on the enemy. For Archimedes had placed most of his engines behind the walls, and not only out of the reach, but even out of the sight, of the enemy; so that the Romans were repulsed with a dreadful slaughter, without seeing the hand that occasioned it; as if they had been fighting, to use Plutarch's expression, not with men, but with the gods themselves. What most harassed the Romans in the attack by sea, was a sort of crow with iron claws, fastened to a long chain, which was let down by a kind of lever. The weight of the iron made it fall with great violence, and drove it into the planks of the galleys. Then the besieged, by a great weight of lead at the other end of the lever, weighed it down, and consequently raised up the iron of the crow in proportion, and with it the prow of the galley to which it was fastened, sinking the poop at the same time into the water. After this the crow letting go its hold all of a sudden, the prow of the galley fell with such force into the sea, that the whole vessel was filled with water, and sunk. At other times, the machines, dragging ships to the shore by hooks, dashed them to pieces against the points of the rocks which projected under the walls. Other vessels were quite lifted up into the air, there whirled about with incredible rapidity, and then let fall into the sea, and sunk, with all that were in them. How these stupendous works were effected, few, if any, have hitherto been able to comprehend.

The troops under the command of Appius suffered no less in this second attack than the fleet. In the whole space of ground which the army, when formed, took up, the last files as well as the first were overwhelmed with showers of darts and flints, against which they could not possibly defend themselves. When they had with infinite trouble brought the mantelets and covered galleries, under which they were to work the rams, near the foot of the wall, Archimedes discharged such large beams and stones upon them as crushed them to pieces. If any brave Roman ventured to draw too near the wall, iron hooks were immediately let down from above, which, taking hold of his clothes or some part of his body, lifted him up in the air and dashed out his brains with the fall. Marcellus, though at a loss what to do, could not however forbear expressing himself with pleasantries: Shall we persist, said he to his workmen, in making war upon this Briareus, upon this giant with an hundred hands? But the soldiers were so terrified, that if they saw upon the walls only a small cord, or the least piece of wood, they immediately turned their backs and fled, crying out, that Archimedes was going to discharge some dreadful machine upon them.

The consuls, finding themselves thus defeated in every attempt, turned the siege into a blockade, reduced most of the other places in the island, and defeated the forces which were sent against them; and at last Marcellus made himself master of Syracuse itself, of which the following account is given by Mr Hooke. "He took the opportunity of a festival, when the soldiers and citizens had drunk plentifully, to make a detachment scale the walls of Tyche, in that part

Syracuse.

70 The siege turned into a blockade.

71 M. Hooke's account of the taking of Syracuse.

Syracuse. of it which was nearest to Epipolæ, and which was ill guarded. He presently after possessed himself of Epipolæ; whereupon the inhabitants of Neapolis, as well as Tyche, sent deputies to him, and submitted. Marcellus granted life and liberty to all of free condition, but gave up those quarters of the city to be plundered.

"Notwithstanding this, there was a great deal yet to do. Acradina and Ortygia, which were strongly fortified, still held out; Hippocrates and Himilco arrived with their troops to the relief of the besieged; and the Romans were forced to exert all their bravery and skill to maintain the advantages they had gained.

"But now a plague made terrible havock in both armies. At the first breaking out of the pestilence, the Sicilians, who served under Hippocrates and Himilco, disbanded themselves, and returned to their respective homes; but all the Carthaginian soldiers perished, together with those two generals. The Romans suffered less by the infection; because, having been a long time before Syracuse, they were seasoned to the air and water of the country.

"About this time Bomilcar arrived on the coast of Sicily from Carthage, with a fleet of 130 galleys and 700 ships of burden; but was long hindered by contrary winds from doubling the cape of Pachynum. Epicydes, fearing the Carthaginian might sail back to Africa, left the command of Acradina to the generals of the mercenaries, and went to Bomilcar, in order to persuade him to fight the Roman fleet. The admiral would not engage, but sailed away to Tarentum with all his galleys, ordering his ships of burden to return to Africa. Epicydes, thus frustrated of his hopes, and knowing himself unable to defend a city already half taken, retired to Agrigentum; whereupon the Syracusians massacred the commanders appointed by him, chose new prætors to govern in the town, and sent deputies to Marcellus to treat of peace. In the mean time, the deserters, fearing to be given up to the vengeance of the Romans, persuaded the mercenaries that they also would have the same fate. Instantly the soldiers ran to arms, put to death the new prætors, together with many of the Syracusians, and plundered part of the city. After this slaughter they chose six generals, three to command in Acradina, and three in Ortygia. Upon the return of the deputies from Marcellus, the mercenaries finding that their case was different from that of the deserters, and that there was no design against their lives, became perfectly satisfied, and the negotiation went on. During the course of the treaty, Marcellus found means to corrupt Mericus, a Spaniard, one of the six generals chosen by the soldiers, and engaged him to admit the Romans into that part of the city where he commanded. Mericus, the better to accomplish this design, feigned an extraordinary zeal for the preservation of that place; pretended not to like that deputies should have leave to go out and in at pleasure; and proposed, that for the greater security of the town, each general should have a distinct quarter assigned him, and be responsible for any neglect of duty in it. The motion was agreed to; and upon the division, that district of Ortygia which extended from the fountain of Arethusa to the mouth of the great port fell to his care. Marcellus, informed of what was done, took his measures accordingly. He sent a body of troops to that side where Mericus commanded, and the Spaniards admitted them at the gate of Arethusa. At the same time, the proconsul ordered a false attack to be made on Acradina; which drawing almost all the soldiers of the garrison thither, Ortygia was in a manner left defenceless. Foreseeing this, he had detached another party of soldiers to take advantage of it. These entered Ortygia almost without fighting; upon which the deserters made their escape,

the Romans giving them way; and the Syracusians in Acradina, thus delivered from the fear of the deserters, immediately opened their gates to Marcellus, who thereby became master of the whole city.

"And now the conqueror, who is said to have wept during the siege with compassion for the inhabitants, gave up both Ortygia and Acradina to be plundered by his army, after he had secured the late king's treasures for the use of his republic, and the statues, paintings, and principal ornaments of Syracuse to illustrate his triumph. The soldiers had orders to spare the lives of the citizens; but they were cruel in their avarice, slew many of them, and among the rest the incomparable Archimedes. He was very intent on a demonstration in geometry, and calmly drawing his lines, when a soldier entered the room, and clapped a sword to his throat. "Hold! (said Archimedes) one moment, and my demonstration will be finished." But the soldier, equally regardless of his prayer and his demonstration, killed him instantly. There are different accounts of the manner of his death; but all agree that Marcellus regretted it extremely, and showed a singular favour to his relations for his sake."

"The city of Syracuse continued subject to the western empire till its declension, when the island of Sicily, being ravaged by different barbarians, the capital also underwent various revolutions; till at last, in the 9th century, it was so destroyed by the Saracens, that very few traces of its ancient grandeur are now to be seen. "The ancient city of Syracuse was of a triangular form, and consisted of five parts or towns. The circuit, according to Strabo, amounted to 180 stadia, or 22 English miles, and four furlongs. An account (says Mr Swinburne) which I once suspected of exaggeration; but, after spending two days in tracing the ruins, and making reasonable allowances for the encroachments of the sea, I was convinced of the exactness of his measurement."

"At present it is strongly fortified towards the land, and the ditches of the bastions form the communications between the two havens. It is very weak towards the sea, but the shelves render it hazardous to debark on that side. The garrison is one of the best appointed in the kingdom, but the heights of Acradina command the works.

"About eighteen thousand inhabitants are now contained in it. The dwellings are far from being memorials of ancient Syracusan architecture or opulence. In any other situation they might be thought tolerable; but to observers who reflect on the style of those buildings that probably once covered the same ground, the present edifices must have a mean appearance. The ancient temple of Minerva is now turned into a cathedral. The walls of the cella are thrown down, and only as much left in pillars as is necessary to support the roof; the intercolumniations of the peristyle are walled up. This temple is built in the old Doric proportions used in the rest of Sicily; its exterior dimensions are 185 feet in length and 75 in breadth. There are also some remains of Diana's temple, but now scarcely discernible. Besides these, there are few ruins in the island; and one is surprised that any should exist in a place which has been so often laid waste by enemies, and so often shaken by earthquakes.

"Every object here imprints a melancholy sensation on the mind, while it draws a comparison between the present humble state of things and their once flourishing condition. The ancients have left pompous descriptions of the traffic carried on in this well situated port, the almost incredible wealth possessed by its citizens, and the splendid edifices upon which they lavished a great part of their riches. I had already viewed (says Mr Swinburne) the desert sites of

72

The city
plundered,
and Archi-
medes killed.

73

Syracuse
destroyed
by the Sa-
racens.Travels
in the Two
Sicilies,
vol. ii.
p. 327,
&c.

Syria, of many great ancient cities, and had as often mourned over their remains, but never did I feel the impression of pity and regret so strong as in wandering among the ruins of Syracuse."

SYRIA, a very ancient kingdom of Asia, lying between the Mediterranean on the west, the Euphrates on the east, and Arabia Deserta, Phœnicia, and Palestine, on the south.

Names, divisions, &c. of ancient Syria.

In ancient times this country was called *Aram*, from Aram the youngest son of Shem, who settled here; but in process of time the name came to be changed into *Syria*, from one *Syrus*, according to some; though others think it is only a contraction of the word *Assyria*. At first it was undoubtedly parcelled out into several petty states; all of which seem afterwards to have been reduced under subjection to the four principal ones, Zobah, Damascus, Hamath, and Geshur. Afterwards the whole country was divided into two parts only, viz. Cœlesyria and Phœnicia; though the Phœnicians, Idumeans, Jews, Gazites, and Azotites, or the whole country of the Philistines, was included. After the death of Alexander, Syria, in the great extent of the word, was divided, according to Strabo, into Comagene, Seleucis of Syria, Cœlesyria, Phœnicia on the sea coast, and Judea in the midland. Ptolemy, however, subdivides these; and in the Proper Syria reckons only Comagene, Pieria, Cyrrhistic or Cyrrhæstia, Seleucis, Cassiotis or Casiotis, Chalybonitis, Chalcidice or Chalcidene, Apamene, Laodicene, Phœnicia Mediterranea, Cœlesyria and Palmyrene.

The history of the ancient Syrians, till the time of their being carried away by the kings of Assyria, is totally unknown, excepting a few particulars which may be gathered from Scripture, and which it is needless here to repeat. During the continuance of the Assyrian, Babylonian, and Persian monarchies, the history of this country affords nothing remarkable; but after the death of Alexander, it gave name to a very considerable empire, which makes a conspicuous figure in ancient history. At this time, however, it was not confined to Syria properly so called, but comprehended all those vast provinces of the Upper Asia which formed the Persian empire; being, in its full extent, bounded by the Mediterranean upon one side, and the river Indus on the other. The first king was Seleucus, one of the generals of Alexander the Great; who, after the death of that conqueror, being made governor of Babylon, was tempted, by the example of Alexander's other captains, to set up for himself. Eumenes, who had sincerely at heart the interest of Alexander's family, solicited his assistance against Antigonus, who had openly revolted; but Seleucus not only refused this assistance, but attempted to destroy Eumenes himself with his whole army, by cutting the sluices of the Euphrates, and laying under water the whole plain where they were encamped. Eumenes, however, found means to escape the danger without the loss of a man. Upon this Seleucus endeavoured to gain over his troops: but finding that impossible, he made a truce with Eumenes, and granted him a safe passage through his province; but at the same time sent an express to Antigonus, desiring him to fall upon him before he was joined by the governors of Upper Asia. Antigonus did not fail to follow his advice; but having prevailed against Eumenes through treachery, he next thought of bringing Seleucus himself under subjection. On his return to Babylon, therefore, after having been feasted with his whole army by Seleucus, he demanded of him an account of the revenues of his province. Receiving an unfavourable answer to this question, Antigonus was so much exasperated, that Seleucus, not thinking himself a match for him at that time, thought proper to fly into Egypt.

Obliged by Antigonus to fly into Egypt.

By the flight of Seleucus, Antigonus was left master of

all his provinces; but his son Demetrius being afterwards defeated by Ptolemy at Gaza, Seleucus began to think of recovering what he had lost. Being furnished by Ptolemy with 1000 foot and 200 horse, he set out with that slender force to attempt the recovery of Babylon. Nothing could have a more desperate appearance than this undertaking; yet Seleucus was not discouraged. On his arrival at Carrhæ in Mesopotamia, partly by force and partly by persuasion, he prevailed on the Macedonians who garrisoned that place to revolt from Antigonus and join him. Being thus reinforced, he entered the territories of Babylon, where new supplies were continually added to his army; his ancient subjects flocking to him from all parts, and declaring themselves ready to stand by him with their lives and fortunes. This happened in consequence of the lenity with which they had been treated by Seleucus; whereas Antigonus was universally detested on account of his severity. — As he approached the city, those who favoured Antigonus retired into the citadel, but were soon obliged to surrender; and in that fortress Seleucus found his children, friends, and domestics, whom Antigonus had kept prisoners ever since his flight into Egypt.

Seleucus having thus made himself master of Babylon, in the year 312 B. C. began to prepare for encountering Antigonus, who he knew would soon attack him with all his force. Nicanor, governor of Media under Antigonus, first advanced against him at the head of 10,000 foot and 7000 horse; but Seleucus, with only 3000 foot and 400 horse, having drawn him into an ambush, cut off almost the whole of his army, and such of the soldiers as had escaped the slaughter willingly enlisted under his banner.

The consequence of this victory was the submission of all Media and Susiana; which alarming Antigonus, he sent his son Demetrius with an army of 5000 Macedonian foot, 10,000 mercenaries, and 4000 horse. Seleucus was then in Media; and Patrocles, whom he had left to take care of Babylon, finding his force inadequate to that purpose, compelled the inhabitants to leave the city and disperse themselves in the adjacent countries, while he himself, with what troops he had, retired into two forts, which he thought could easily be defended. When therefore Demetrius entered Babylon, he was surprised to find it deserted, upon which he instantly attacked the forts. One was quickly reduced; but as the other held out till the expiration of the time which had been allowed him by his father, he left 5000 foot and 1000 horse under the command of Archelaus to carry on the siege. With the rest he marched away, suffering his soldiers to live at discretion as he went along; which so provoked the Babylonians, that they were ever after attached to Seleucus as if he had been their natural prince.

On the return of Seleucus to Babylon, he easily drove out the troops left by Antigonus, recovered the castle which he had garrisoned, and settled his authority on such a firm foundation, that it could never afterwards be moved. Having then marched again into Media, he defeated and killed with his own hand Nicanor or Nicator, whom Antigonus had sent against him; after which, having settled the affairs of Media, he reduced all Persia, Bactria, and Hyrcania, subjecting to his new empire these and all the other provinces on this side the Indus which had been conquered.

Seleucus being now master of all the countries which lie between the Euphrates and the Indus, took the title of king of Babylon and Media. But, not satisfied with these possessions, ample as they were, he crossed the Indus, in order to conquer those regions which had submitted to Alexander beyond that river. But, during the time that the generals of Alexander had been making war upon his family and up-

Syria. on one another, one Sandracottus, a native of India, had driven out the Macedonians, and made himself master of the whole country. He opposed Seleucus with an army of 600,000 men, and a prodigious number of elephants; which intimidated the Macedonian so much, that he offered to leave Sandracottus in quiet possession of his dominions, provided he would furnish him with 500 elephants. To this Sandracottus readily assented; upon which Seleucus marched back into the west against Antigonus, and, in conjunction with Lyfimachus and Ptolemy, engaged and totally defeated and killed him at Ipsus. After this Seleucus marched into Upper Syria, which he reduced entirely, and built the city of Antioch on the Orontes. In the same country he built several other cities; one of which he called *Seleucia*, from his own name; another *Apamea*, from his wife Apama, the daughter of one Artabazus a Persian; and a third *Laodicea*, from his mother Laodice. He first entered into an alliance with Demetrius, and married Stratonice his daughter; but soon after assisted Lyfimachus and Ptolemy to deprive him of the best part of his dominions. Thus Demetrius being reduced so low that he could give him no farther jealousy, Seleucus betook himself to the building of another city, which he called likewise *Seleucia*, and which stood on the place where the city of Bagdad now stands. Besides these, he built a great many others; 16 of which he called *Antioch*, from the name of his brother Antiochus; nine *Seleucia*, from his own name; three *Apamea*, from Apama his first wife; one *Stratonicea*, from his second wife Stratonice; and six *Laodicea*, from his mother Laodice.

In 284 Seleucus entered into a war with Lyfimachus, with whom he had hitherto lived in strict amity. Out of 36 general officers left by Alexander the Great, they two only survived, and both were upwards of 70 years old. Nevertheless they were both filled with the ambition and animosity of young men. The two armies met at a place called *Cuopedion* in Phrygia, where an obstinate engagement took place. Victory was long doubtful: but at last Lyfimachus was run through with a spear, and died on the spot; on which his troops betook themselves to flight, and left Seleucus master of their baggage. This victory added to the possessions of Seleucus all those provinces which had formerly been subject to Lyfimachus. The former exulted much in his good fortune; being chiefly pleased that he was now the last of Alexander's captains, and by this victory became, as he styled it, *the conqueror of conquerors*; and on this account he is generally called *Nicator*, or *the conqueror*. His triumph, however, on this occasion, was but short-lived; for, seven months after, as he was marching towards Macedon to take possession of that kingdom, he was treacherously murdered by Ptolemy Ceraunus, on whom he had conferred innumerable favours. Philetærus prince of Pergamus purchased his body at a great price from Ptolemy, and sent it to his son Antiochus; who, with extraordinary pomp, burned it in Seleucia on the sea-coast, erecting on the place a magnificent chapel, which he called from his surname *Nicatorium*.

Seleucus was succeeded by his son Antiochus Soter, who held the empire 19 years. He resigned to Antigonus Gonatus all pretensions to the crown of Macedon; and having engaged in a war with Eumenes king of Pergamus, he was defeated by him, and obliged to yield up part of his dominions. He died in 261 B. C. and was succeeded by his son Antiochus Theos; who having engaged in a war with Ptolemy Philadelphus king of Egypt, the Parthians and Bactrians took an opportunity to revolt, and could never afterwards be reduced. In 246 B. C. he was poisoned by his wife Laodice, whom he had divorced for Berenice daughter

to Ptolemy, with whom he made peace on the revolt of the Bactrians. On the death of Ptolemy, Antiochus divorced Berenice, and took back Laodice; who, to secure herself against the effects of his fickle disposition, poisoned him, as we have just mentioned, and raised to the throne her own son, named *Seleucus Callinicus*. Not thinking herself safe, however, as long as Berenice lived, Laodice began immediately to concert measures for putting both her and her son to death. Berenice attempted to save herself by retiring to Daphne, where she shut herself up in an asylum built by Seleucus Nicator. There she was closely besieged by the sons of Seleucus; of which the cities of Asia having intelligence, formed a confederacy in her favour. Her brother the king of Egypt also hastened to her relief with a considerable army; but before either of these could come to her assistance, both she and her son were barbarously murdered, with all the Egyptians who attended them.

Ptolemy, on hearing the melancholy news of his sister's death, determined to take the most severe vengeance on her murderers. Joining his forces to those of the Asiatics, he carried every thing before him. Having in the first place put an end to the life of Laodice, he made himself master of all Syria and Cilicia; then passing the Euphrates, he subdued all the country as far as Babylon and the Tigris; and had not the progress of his arms been interrupted by a sedition which obliged him to return to Egypt, it is more than probable that he would have subdued the whole Syrian empire. As soon as he was returned, Seleucus attempted to revenge himself; but his fleet being destroyed by a violent storm, and his land-army defeated by Ptolemy, he concluded a truce for ten years. During all this time the Parthian prince had established himself so firmly on the throne, that it was in vain to think of dispossessing him. However, as soon as his other affairs would permit, Seleucus undertook an expedition against Arsaces the Parthian monarch; by whom he was utterly defeated, taken prisoner, and carried into Parthia, where he died four years after. He was succeeded by his eldest son Seleucus Ceraunus, a weak prince, who was poisoned by a conspiracy of two of his officers, when he had reigned one year; after which his brother Antiochus, surnamed the *Great*, ascended the throne in 225 B. C.

In the very beginning of his reign, two of his generals, Alexander and Molo, rebelled against him. The former had been appointed governor of Persia, and the latter of Media; but they, despising the king's youth, refused to obey. The occasion of this revolt is said to have been their dread of the cruelty of Hermias the king's prime minister; and as they hoped to draw into their schemes Achæus governor of the provinces of Asia Minor, they doubted not of success. In this, however, they failed; but this did not discourage them from proceeding in their rebellion. Epigenes, the commander of the troops about the king's person, advised him to march without delay against the rebels; but as Hermias reproached him with treachery and a design to betray the king into the hands of his enemies, Antiochus sent two of his generals into the east, while he himself undertook an expedition against Ptolemy Philadelphus, with a view of recovering Coelestria. In this attempt, however, he was disappointed; and the generals whom he had sent into the east were totally defeated, and their troops cut off: upon which he determined to lay aside for the present his Syrian enterprise, and march in person against the rebels. This was again opposed by Hermias; but as he found it impossible to alter the king's mind, the treacherous minister found means to get Epigenes the author of this project executed, under pretence of holding a correspondence with Molo one of the rebel chiefs. Antiochus in the mean time pursued his

9
Cedes India
to Sandro-
cottus for
500 ele-
phants.

10
Defeats An-
tigonus, and
builds many
cities.

11
Defeats and
kills Lyfi-
machus.

12
Is himself
treacherous-
ly murder-
ed.

13
Antiochus
Soter.

14
Antiochus
Theos.

Syria.
15
Seleucus
Callinicus.

16
Great part
of his do-
minions
conquered
by Ptolemy
Evergetes.

17
Seleucus
defeated
and taken
prisoner by
the Par-
thians.

18
Antiochus
the Great.

19
Undertakes
an un suc-
cessful ex-
pedition a-
gainst E-
gypt.

Syria. his march against the rebels, whom he defeated in a pitched battle; upon which their chiefs laid violent hands on themselves. On his return he received the submission of the Atropatii, a barbarous people in Media; and put to death his prime minister Hermias, whom he found hatching treacherous designs against him. During his lifetime, however, the traitor, by accusing Achæus of treason, had obliged him to revolt in his own defence; so that the king had still two important wars on his hands, viz. that with Ptolemy king of Egypt, and the other against Achæus. After some deliberation, he resolved to march first against the king of Egypt; and was at first very successful, reducing many cities in Coelestria and Palestine, and defeating the Egyptians in a pitched battle: but in the year 217 B. C. being worsted in the battle of Raphia, he was obliged to abandon all his conquests; of which Ptolemy immediately took possession, and Antiochus was obliged to cede them to him, that he might be at leisure to pursue the war against Achæus.

20 Suppresses one rebellion, but is embarrassed by another.

21 Is defeated by the Egyptians, but suppresses the rebellion.

Antiochus having made vast preparations for his expedition, soon reduced Achæus to such distress, that he was obliged to shut himself up in the city of Sardis, which he defended for some time with great bravery; till at last, being betrayed by two Cretans, he was delivered up to the king, and by his order put to death. Antiochus then undertook an expedition against the Parthians, whom he obliged to conclude a peace on very advantageous terms. He then turned his arms against the king of Bactria, whom he also compelled to agree to his terms; one of which was, that he should give him up all his elephants. For the confirmation of the treaty, the king of Bactria sent his son to Antiochus; who being taken with his majestic mien and agreeable conversation, gave him one of his daughters in marriage. He then crossed Mount Caucasus, and entered India; where having renewed his alliance with the king of that country, he received also of his elephants, which increased his stock to 150. From India he marched into Arachosia, Drangiana, and Carmania, establishing order and discipline in all those countries: then passing through Persia, Babylonia, and Mesopotamia, he returned to Antioch, after an absence of seven years.

22 His successes in the east.

23 Enters into a league with Philip of Macedon against the king of Egypt.

In the year 204 B. C. Antiochus entered into a league with Philip of Macedon, on purpose to deprive Ptolemy Epiphanes, the infant king of Egypt, of all his dominions. The Egyptians, however, put the young king under the tuition of the Romans; who immediately required the confederate princes to desist from any enterprise against the king of Egypt, under the penalty of incurring the displeasure of the republic. After delivering this message, M. Emilius Lepidus, one of the ambassadors, repaired to Egypt, where he took upon himself the office of regent and guardian to the young king. Having regulated affairs there in the best manner he could, he returned to Rome, after having appointed one Aristomenes, an Acarnanian, to be chief minister to the king. Aristomenes being a man of prudence and fidelity, acquitted himself very well in his new station. Having taken care to recruit his army as well as he could, he sent one Scopas, a man of great authority among the Ætolians, into that country, to raise auxiliaries. Scopas soon raised an army of 6000 Ætolians, at that time reputed the best soldiers in the world; and having joined the Egyptian army, reduced all Judea, put a garrison into the castle at Jerusalem, and, on the approach of winter, returned to Alexandria loaded with booty. These exploits, however, were performed when Antiochus was absent in Asia Minor; and no sooner was he returned, than the face of affairs was changed. Scopas was defeated in a pitched battle, where one half of his men were destroyed. He himself escaped to Sidon, where he shut himself up with 10,000 of his sol-

24 Destroys the Egyptian army.

diers; but Antiochus having invested the place, Scopas was reduced to the necessity of surrendering at discretion. The king pursued his conquests; recovered all Palestine and Coelestria; after which he invaded Asia Minor, in hopes of reducing it also, and restoring the Syrian empire to the same extent it had in the time of Seleucus Nicator. The free cities in Asia Minor immediately had recourse to the Romans, who sent an embassy to Antiochus on the occasion; but as both parties put on those haughty and imperious airs to which they thought the greatness of their power gave them a right, no satisfaction was given, but every thing tended to an open rupture. While matters were in this situation, Hannibal the Great being obliged to leave his own country, fled to Antiochus: from whom he met with a gracious reception. As Hannibal had, while a child, sworn perpetual enmity against the Romans, he used all his eloquence to persuade Antiochus to make war with them; and as the many victories which he had gained over them left no room to doubt of his capacity, Antiochus doubted nothing of being able, by his assistance, to conquer that haughty people. Several embassies passed between the two nations; but chiefly with a design, on the part of Antiochus, to gain time. Hannibal endeavoured to draw his countrymen into the confederacy against Rome, but without effect. Antiochus having strengthened himself by several alliances, at last resolved to begin the war in earnest. To consult on the measures proper to be taken, he called a council of war; but excluded from it the only man whose advice he ought to have followed; namely, Hannibal the Carthaginian. The reason of this was, that he had become jealous of him from the too great intimacy, as he thought, which he had kept with the Roman ambassadors. However, in this council it was agreed that the war should be immediately commenced. The King himself was prevailed upon by the Ætolians to pass over into Greece, and at the same time entirely to reject the advice which Hannibal had formerly given, of sending him with an army into Italy. Here he was made generalissimo of all the Greek forces; but made none of those efforts that had formerly obtained him the title of Great. Indeed it now plainly appeared, not only that he was incapable of carrying on war against such enemies as the Romans, but even of accepting proper advice when it was given him. In another council, into which Hannibal was admitted, that commander advised the king, before he undertook any thing else, to use his utmost endeavours to gain over Philip of Macedon; which, he said, was a step so important, that if it could be gained, they might, without much ado, become masters of all Greece. But if Philip could not be prevailed on to make war on the Romans, he was of opinion that the king should send his son Seleucus into Macedon at the head of an army, and thus prevent Philip from giving the Romans any assistance. But he still maintained, that the only way to defeat the Romans was to send an army into Italy. This advice was again rejected; and the king imprudently became the aggressor, by falling on a body of 500 Romans before war had been declared. He also made king Philip his enemy, by entertaining the regent of Athamania, who was a pretender to the crown of Macedon. To complete all, he himself fell in love, though above 50 years of age, with a beautiful young woman of Chalcis, whom he married; and became so great a slave to this passion, that he entirely neglected his affairs; the army gave themselves up entirely to dissipation and debauchery, and every trace of military discipline vanished.

25 His conquests checked by the Romans.

26 Hannibal flees to him for protection.

27 Antiochus neglects the advice of Hannibal.

28 His shameful behaviour.

In the year 191 B. C. Antiochus was raised from his lethargy by a declaration of war against him at Rome, and set out for Ætolia. His army at this time amounted to no more than 10,000 foot and 500 horse. He had been made

Syria.
19
Is defeated
by the Ro-
mans at
Thermopy-
la.

to believe that he would receive a vast reinforcement in Ætolia; but when he came to make the experiment, he soon found his mistake; all the troops he could raise there amounted to no more than 4000 men. With this force, so exceedingly inadequate to the purpose, he was obliged to oppose the Roman army, who were advancing in conjunction with the Macedonians, and had already made surprising progress. Antiochus seized the Straits of Thermopyla; but was driven from them by the Romans, the king himself being the first that fled. Almost his whole army was destroyed in the battle or in the pursuit, and Antiochus returned with disgrace into Asia.

30
His fleet
defeated by
that of the
Romans.

Soon after his return, Antiochus equipped a fleet of 200 sail; on which he immediately embarked for the Thracian Chersonesus, now Crim Tartary, where he fortified the cities of Lysimachia, Sestus, and Abydos, with others in that neighbourhood, to prevent the Romans from crossing the Hellespont. In the mean time Polyxenidas the Syrian admiral sent intelligence to the king that the Roman fleet had appeared off Delos; upon which he desired him to seek them out and engage them at all events. He did so, and was defeated with the loss of 40 ships taken or sunk in the engagement. This was soon after revenged by the destruction of the Rhodian fleet by the artifice of Polyxenidas; but in the end the king's affairs went everywhere to wreck. Having laid siege to the city of Pergamus, he was obliged to raise it with loss; the Phœnician fleet commanded by Hannibal was defeated by the Rhodians; and soon after the Syrian fleet under Polyxenidas was utterly defeated by the Romans. Antiochus was so much disheartened by these repeated defeats, that he appeared like one infatuated. Instead of fortifying more strongly those cities which lay on the frontiers of his kingdom, he entirely deserted them: and thus Lysimachia and Abydos, the two keys to Asia, fell into the hands of the Romans without the least resistance.

31
Meets with
two other
defeats, and
becomes
like one in-
fatuated.

32
Sues for
peace, but
is refused.

The arrival of the Romans in Asia struck Antiochus with such terror, that he instantly sued for peace. The terms he offered were indeed very advantageous, but by no means agreeable to the expectations of the Romans. They therefore gave him this final answer: 1. That since he had drawn upon himself the war, he should defray the whole expence of it; 2. That he should restore liberty in general to all the Greek cities in Asia; and, 3. That to prevent future hostilities, he should relinquish all Asia on this side Mount Taurus. These terms, however, still appeared to him so intolerable, that he resolved to continue the war; and determined also to take the most imprudent method of carrying it on, namely, by hazarding all on the event of a general engagement. The king encamped near Magnesia, and strongly fortified his camp. The Romans insulted him in his trenches, and proposed to attack his fortifications if he continued to decline an engagement. At last the king, thinking it would be shameful for him longer to refuse an engagement, being at the head of an army far more numerous than that of the enemy, in a friend's country, and in the midst of his allies, resolved at all events to accept the challenge, and accordingly prepared for a decisive battle.

33
Battle of
Magnesia.

The Roman army consisted of four legions, partly Romans and partly Latins, each legion at this time containing 5500 men, and of 7000 auxiliaries sent by the kings of Pergamus and Macedon; but of these 2000 were ordered to guard the camp during the action. The Romans were posted in the centre, and the Latins in the two wings, the left of which extended to the river. On the side of the right wing, to cover and support it, the consul posted the auxiliary troops of Eumenes, a small body of horse, and some Trallians and Cretans lightly armed. Sixteen elephants which the Romans had were placed behind the army by way

of corps-de-reserve, the consul not thinking it proper to oppose them to those of the enemy, which were far more numerous, being in all 52, and besides excelled the Roman elephants in strength, height, and courage, the former being brought from India and the latter from Africa. As for the Syrian army, all the nations of the east seemed to be assembled to support the cause of Antiochus. But the main strength of it consisted in 16,000 foot, armed after the Macedonian manner, who composed the phalanx. This body faced every way, was armed with long pikes, and taught to fight in close order, as the soldiers of Alexander the Great had formerly been. Antiochus did not draw up his phalanx as usual, but divided it into 10 companies separated from each other, placing, in the spaces between each of the companies, an elephant loaded with a tower full of armed men. On the right of the phalanx was drawn up in a line part of the cavalry, viz. 1500 Asiatic Gauls, 3000 horse armed cap-a-pee, and 1000 more, the flower of the Median cavalry. At some distance from these followed the cavalry of the king's household richly clothed, and wearing bucklers plated over with silver. In the same line 1200 Scythians on horseback, armed with bows and arrows, made a great figure, being all chosen men, and of an extraordinary size. The light-armed troops, to the number of 3000, partly Trallians and partly Cretans, with 10,000 Mysian archers and 4000 men more, partly Cyrtæans armed with slings, partly Persians armed with bows, and partly Arabians mounted on dromedaries, closed the right wing, which was led on by the king in person, surrounded by a body of Syrians and Lydians well mounted, but not heavily armed. The left wing was commanded by Seleucus and Antipater; the former the king's son, and the latter his nephew, and disposed thus: Close to the phalanx were posted 1500 Galatians and 2000 Cappadocians, which king Ariarathes had sent to the assistance of his father-in-law. Next to these were placed 2700 auxiliaries sent from different countries; these were followed by 3000 cuirassiers well mounted; and, lastly, in the flank of this wing marched 2000 horse lightly armed. At some distance were placed several small bodies of light-armed troops both foot and horse; among which were 2500 Galatian horse, some Tarentines, Cretans, Carians, Cilicians, &c. The phalanx, which was in the centre, was commanded by three officers of distinction, viz. Minio, Zeuxis, and Philip. A vast number of chariots, armed with hooks and scythes, were drawn up before the first line, as were likewise a great many elephants carrying towers with several floors, all filled with slingers and archers; besides many camels, animals then unknown to the Roman troops, mounted by Arabians armed with swords six feet long, that the riders might from their backs reach the enemy. The Romans had never seen a more numerous army, nor one more finely adorned; nevertheless they never showed so great a contempt for an army as for this which they were now going to attack.

On the day of the battle the weather proved very favourable to the Romans; for a thick fog rising in the morning, the day was almost turned into night, so that the Syrian commanders could not have all the corps under their command in view, on account of their great extent, nor send them proper orders in time; whereas the fog was not thick enough to prevent the Roman generals from seeing their several bodies at the greatest distance, as they took up but little ground. Besides, the damp which was occasioned by the fog slackened the strings of the enemy's bows, so that the Asiatics who used them could shoot their darts and arrows but faintly. The whole dependence of Antiochus in the first attack was on his armed chariots, which were to cut their way into the Roman army. For this purpose they had

Syria.

Syria. had long halberts fastened to their poles, and sharp hooks to their axle-trees; the former were about the height of a man's head, and the latter almost swept the ground, and cut off the legs of all who stood in their way. But Eumenes undertook to render them useless, and even fatal, to the enemy. This brave prince, putting himself at the head of the bowmen and slingers, ordered them to charge, not in a body, but divided in platoons, and to aim only at the horses in the chariots. Accordingly, as soon as the chariots moved, Eumenes advanced at the head of his men, who pouring on them from every quarter darts, stones, and javelins, and at the same time shouting as loud as they could, so frightened the horses that they could no longer be kept in order, but scouring up and down, and turning against their own troops, fell on the Arabians who supported them, which occasioned a great confusion in that quarter. Those in the Syrian army who were at a distance, hearing the noise and outcries, and not knowing the cause of them, were struck with no small terror. After this advantage, the Roman cavalry advanced, and fell on those whom the chariots had put in disorder. The Syrians being already intimidated, after a faint resistance gave way; and the Romans made a great slaughter of their men and horses, both being borne down with the weight of their heavy armour. Eumenes charged the left-wing, in which Seleucus commanded, with such vigour, that he put it to flight; and the fugitives flying to the phalanx for protection, put that body likewise in disorder: which Domitius observing, advanced against it at the head of his legionaries, but could not break it till he ordered his men to attack the elephants; which, as before observed, were placed in the spaces between the companies. The Romans had learned, in their wars with Pyrrhus and Hannibal, not to fear those monsters which were once so terrible to them. They attacked them, therefore, with great resolution; and driving them against the phalanx, put that body into disorder, by means of those very animals which had been posted there for its defence.

34
Gallant behaviour of Eumenes.

35
The Syrians defeated.

But in the mean time advice was brought that the left wing of the Romans was in great danger. Antiochus, who had observed that the flanks of the left wing were quite open and uncovered, the four squadrons which covered it having joined the rest of the cavalry to fall upon the enemy's left wing, had charged it at the head of all his auxiliaries, not only in front but in flank. The Roman infantry, seeing themselves in imminent danger of being surrounded and hemmed in on all sides, fled in great disorder to their camp, which was guarded by 2000 men under the command of a legionary tribune called *Æmilius*. This man seeing the Romans flying towards him, marched out at the head of all his troops to meet them; and after having bitterly reproached them for their cowardice and ignominious flight, ordered his men to draw their swords, and cut in pieces such as should advance one step farther, or refuse to face about against the enemy. This order, given so seasonably, and put in execution without mercy against some, had the desired effect. Those who were flying first halted; and then, being both reinforced and encouraged by *Æmilius*, returned under his conduct to wipe off the dishonour of their flight. At the same time Attalus the brother of Eumenes, having left the right wing on his receiving advice that the left was in danger, arrived very seasonably with 200 horse. Antiochus observing that the troops which had fled were returning to the battle, and that the enemy's right wing was ready to fall upon him, turned his horse about and fled. This served in a manner as a signal for the rest of the troops, for the whole Syrian army immediately turned their backs. Eumenes alone pursued them at the head of the cavalry, and made a most dreadful havock of the fugitives. The

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Romans walking over heaps of dead bodies, especially where the phalanx stood, marched up to the Syrian camp, attacked, and plundered it. The riches they found in it are not to be described; but the taking of it cost the Romans a new battle, which proved more fatal to the Syrians than that in the field; for the Romans having, in spite of a most desperate resistance, forced the intrenchments, gave no quarter, but put all to the sword without distinction. There fell this day in the battle, in the pursuit, and in the plunder of the camp, 50,000 foot and 4000 horse; 1500 were taken prisoners, and 15 elephants. In the consular army there were but 300 foot killed and 25 horse. Eumenes had only 15 of his men killed; so that this victory, as we are told by the ancients, seemed a prodigy to all nations both of the east and west.

Antiochus retired to Sardis with as many of his forces that had escaped the slaughter as he could draw together. From Sardis he soon marched to rejoin his son Seleucus, who had fled to Apamea. As for the consul, he took advantage of the king's defeat and flight, making himself master of all the neighbouring countries. Deputies hastened to him from all parts; the cities of Thyatira, Magnesia, Trallis, Magnesia in Caria, all Lydia, and Ephesus itself, though highly favoured by Antiochus, declared for the Romans. Polyxenidas, upon the news of the king's defeat, left the port of Ephesus, and sailed to Patara, where he landed with a very small guard, and returned by land into Syria. The consul took the road to Sardis, which opened its gates to him. As he stopped there, his brother Africanus, as soon as his health allowed him, came and joined him in that city, and congratulated him on the glory he had so lately acquired.

Antiochus finding his affairs in a bad situation both by sea and land, and not daring to appear before the consular army in the field, sent Antipater his brother's son, and Zeuxis, who had been governor of Lydia and Phrygia, to sue for a peace. They were ordered to treat chiefly with the elder brother, of whose clemency and good nature Antiochus entertained a high opinion. Accordingly, on their arrival at Sardis, where the consul then was with his brother, they addressed the latter, and were by him presented to the consul. Their speech was very submissive, and such as became a vanquished people.

Hereupon a council was summoned, and after long debates the ambassadors were called in; and Scipio Africanus being desired by the consul to acquaint the deputies with the resolutions of the assembly, is said to have expressed himself in the following terms: "We are sensible that the victory which we have lately gained is owing to the gods, and therefore shall treat the vanquished with moderation, demanding little more of them now than we did at our first entering into Asia. Antiochus shall obtain a peace upon the following terms: That he give up his pretensions to Europe, confine his dominions to Asia beyond Mount Taurus; and that he pay 15,000 Euboec talents for the expences of the war; 500 down, 2500 when the senate and people shall confirm the articles, and 1000 more every year for 12 years together. We also insist upon his satisfying king Eumenes, and his paying him the 400 talents he owes him, and what remains due for the corn which his father sent to the king of Syria. It is likewise the pleasure of the council that you deliver up to us Hannibal the Carthaginian, Thoas the Ætolian, Mnesilochus the Acarnanian, and Philo and Eubulus two Chalcidians; for these have been the authors of our divisions, the incendiaries who kindled the present war. Lastly, the king of Syria, for a further proof of his sincerity, shall give us 20 such hostages as we shall choose, of whom Antiochus his youngest son shall be one."

Syria. 36
and their camp taken.

37
Antiochus obtains peace on very hard terms.

L I

The

Syria.

The ambassadors of Antiochus had been ordered to refuse no terms; and therefore these were accepted, and the whole affair concluded. So that the Syrian ambassadors now prepared to set out for Rome, to get the conditions of peace proposed by Scipio ratified there. In the mean time, the consul dividing his army into three bodies, put it into winter-quarters; one part continued at Magnesia, another was sent to Trallis, and the third to Ephesus, where the Scipios took up their quarters. There they received a new embassy from Antiochus, with the hostages he had promised, the Roman prisoners and deserters, and the strangers which the consul had demanded, except Hannibal, who after the king's defeat had fled out of his dominions; and Thoas the Ætolian, who, as soon as he heard that a treaty was on foot between Antiochus and the Romans, had returned to Ætolia, where a war was likely to break out between that republic and Rome. L. Aurelius Cotta was sent with the ambassadors to Rome, to acquaint the senate with the particulars of the treaty. When they appeared before the conscript fathers, they spoke with great submission, and only desired them to ratify the articles which the Scipios had offered to their master. The senate, after examining them, ordered that a treaty of peace should be concluded with Antiochus, and the articles of it engraved on brass, and fixed up in the Capitol. They only added one clause, which was, That the Syrians should change every year all their hostages, except the son of king Antiochus, who should continue at Rome as long as the republic thought fit. The peace being thus ratified, and all Asia on this side Mount Taurus delivered into the hands of the Romans, the Greek cities were by them restored to their liberty, the provinces of Caria and Lydia given to the Rhodians, and all the rest that had belonged to Antiochus bestowed upon Eumenes.

38.
His death.

Antiochus did not long survive his misfortune at Magnesia. Some tell us, that being greatly puzzled how to raise the sum he had engaged to pay to the Romans, he seized on the riches which had for many ages been deposited in a temple of Jupiter Belus in the province of Elymais; upon which the populace rose in arms, and slew him and all his attendants. Others inform us, that he was killed at an entertainment by one of his guests.

Antiochus the Great died in 187, and with him the glory of the Syrian empire. The Romans now gave laws to the kings of Syria, insomuch, that when Antiochus Epiphanes the grandson of Antiochus the Great hesitated at obeying the commands of the senate, one of the ambassadors drew a circle round him with a rod on the floor, and told him that he should not go out of that spot before he had told him what he was to do. The most remarkable transactions of this prince are his wars with the Jews, and persecutions of them; of which a full account is given under the article JEW. After a variety of usurpers and tyrants, the kingdom of Syria fell under Tigranes king of Armenia in the year 83 B. C.; and upon his overthrow by the Romans, it became a province of the dominions of the republic. From them it was taken by the Saracens in the reign of the caliph Omar, and is now a province of Turkey in Asia.

39.
Syria becomes a Roman province.

40.
Climate, soil, &c. of the country.

Syria is in some measure only a chain of mountains, varying in their levels, situation, and appearances. The part of the country, however, next the sea is in general low, and besides this there are several extensive valleys. The climate on the sea-coast and in these valleys is very hot, but in the higher parts of the country it bears a good deal of resemblance to that of France. Syria is exceedingly fertile, and the variety of its productions is very great. Besides wheat, rye, barley, beans, and the cotton plant, which is cultivated everywhere, Palestine abounds in sesamum, from which oil is procured, and doura as good as that of Egypt.

Maize thrives in the light soil of Balbec, and even rice is cultivated with success on the borders of the marshy country of Havula. They have lately begun to plant sugar-canes in the gardens of Saide and of Bairout, and they find them equal to those of the Delta. Indigo grows without cultivating on the banks of the Jordan, in the country of Bisan, and only requires care to make it of an excellent quality. The hill-sides of Latakia produce tobacco. Gaza produces dates like Mecca, and pomegranates like Algiers; Tripoli affords oranges equal to those of Malta; Bairout figs like those of Marseilles, and bananas not inferior to those of St Domingo; Aleppo enjoys the exclusive advantage of producing pistachios; and Damascus justly boasts of possessing all the fruits known in our provinces. Its stony soil suits equally the apples of Normandy, the plums of Touraine, and the peaches of Paris. Twenty sorts of apricots are reckoned there, the stone of one of which contains a kernel highly valued through all Turkey. The cochineal plant, which grows on all that coast, contains perhaps that precious insect in as high perfection as it is found in Mexico and St Domingo.

Syria
System.

The inhabitants may be divided into three principal classes: the descendants of the Greeks of the Lower Empire; the Arabs, their conquerors; and the Turks, the present ruling power: and these again, the first into three, the second into four, classes; besides three wandering tribes of Turkomen, Curds, and Bedouin Arabs. The ancient inhabitants before the Greeks under Alexander are entirely lost. The inhabitants are in general of a middling stature, and the eyes of the women almost everywhere beautiful, and their shape correct and well proportioned. The general language is Arabic. Syriac is a dead language.

SYRINGA, the LILAC, in botany: A genus of plants belonging to the class of *diandria*, and order of *monogynia*; and in the natural system ranging under the 44th order, *Sepiaria*. The corolla is quadrifid, and the capsule is bilocular. There are three species, the *vulgaris*, *persica*, and *suspensa*. The two first are natives of Persia, and the last of Japan.—The *vulgaris*, which is distinguished by ovate heart-shaped leaves, was cultivated in Britain about the year 1597 by Mr John Gerard.—The *persica*, which has lanceolate leaves, was cultivated in 1658; but how long both species might have been introduced into Britain before these dates, it is perhaps impossible to ascertain.

SYRINGE, a well-known instrument, serving to imbibe or suck in a quantity of fluid, and to squirt or expel the same with violence. The word is formed from the Greek *συρίγξ*, or the Latin *syrinx* "a pipe."—A syringe is only a single pump, and the water ascends in it on the same principle as in the common sucking-pump. See HYDROSTATICS, n° 25, *et seq.*

SYRUP, in pharmacy, a saturated solution of sugar, made in vegetable decoctions or infusions. See PHARMACY, ch. xxiii.

SYSTEM, in general, denotes an assemblage or chain of principles and conclusions, or the whole of any doctrine, the several parts whereof are bound together, and follow or depend on each other; in which sense we say a *system of philosophy*, a *system of divinity*, &c. The word is formed from the Greek *συστημα* "composition, compages."

SYSTEM, in the animal economy, the *vascular*, the *nervous*, and the *cellular*. See ANATOMY.

SYSTEM, in music, an assemblage of the rules for harmony, deduced from some common principle by which they are reunited; by which their connection one with another is formed; from whence, as from their genuine source, they natively flow; and to which, if we would account for them, we must have recourse. See the articles CHROMATIC, DIATONIC,

System TONIC, ENHARMONIC, HARMONY, INTERVAL, and MUSIC.

Style SYSTEM, in botany. See BOTANY, page 430.

SYSTEM, in astronomy. See ASTRONOMY.

SYSTOLE, in anatomy, the contraction of the heart, whereby the blood is drawn off its ventricles into the arteries; the opposite state to which is called the *diastole*, or *dilatation of the heart*. See ANATOMY, n° 124.

SYSTYLE, in architecture, that manner of placing co-

lurans where the space between the two shafts consists of two diameters or four modules.

SYZYGY, SYZYGIA, in astronomy, a term equally used for the conjunction and opposition of a planet with the sun. The word is formed from the Greek *συζυγία*, which properly signifies *conjunctio*. On the phenomena and circumstances of the syzygies a great part of the lunar theory depends. See ASTRONOMY.

Syzygy.

T.

T.
Tabanus.

T or t, the 19th letter and 16th consonant of our alphabet; the sound whereof is formed by a strong expulsion of the breath through the mouth, upon a sudden drawing back of the tongue from the fore-part of the palate, with the lips at the same time open. The proper sound of *t* is expressed in most words beginning or ending with that letter; as in *take, tell, hot, put*. *Ti* before a vowel has the sound of *fi*, or rather of *phi*, as in *creation*, except when *f* precedes, as in *question*; and in derivatives from words ending in *ty*, as, *mighty, mightier*. *Th* has two sounds; the one soft, as *thou, father*; the other hard, as *thing, think*. The sound is soft in these words, *then, thence, and there*, with their derivatives and compounds; and in the words *that, this, thus, thy, they, though*; and in all words in which *th* comes between two vowels, as, *whether, rather*; and between *r* and a vowel, as *burthen*.

In abbreviations, amongst the Roman writers, *T.* stands for *Titus, Titius, &c.*; *Tab.* for *Tabularius*; *Tab. P. H. C.* *Tabularius Provinciae Hispaniae Citerioris*; *Tar. Tarquinius*; *Ti. Tiberius*; *Ti. F. Tiberii filius*; *Ti. L. Tiberii libertus*; *Ti. N. Tiberii Nepos*; *T. J. A. V. P. V. D. tempore judicem arbitrumve postulat ut det*; *T. M. P. terminum posuit*; *T. M. D. D. terminum dedicavit*; *Tr. trans, tribunus*; *Tr. M. or Mil. tribunus militum*; *TR. PL. DES. tribunus plebis designatus*; *TR. AER. tribunus aerarii*; *TRV. CAP. triumviri capitales*; *T. P. or TRIB. POT. tribunicia potestate*; *Tul. H. Tullus Hostilius*.

Amongst the ancients, *T.* as a numeral, stood for *one hundred and sixty*; and with a dash at top, thus, *T̄*, it signified *one hundred and sixty thousand*. In music, *T* stands for *tutti*, "all, or altogether."

TABANUS, the BREEZE-FLY: a genus of insects belonging to the order of *diptera*. The mouth is extended in a fleshy proboscis, terminated by two lips. The rostrum is furnished with two pointed palpi placed on each side of the proboscis, and parallel to it. Gmelin has enumerated 38 species; of which three only are found in Great Britain, the *bovinus*, *pluviatilis*, and *cæcutiens*.

1. The *bovinus*, or great horse fly, has a grey head; the eyes almost of a black brown, occupying the greatest part of it. The thorax is of a grey colour; the abdomen is yellowish, with a triangular white spot on the middle of every ring, which constitutes a longitudinal band of spots, the point of which is directed towards the thorax. The thighs are blackish, and the legs yellow. The wings are somewhat dusky, with brown veins of a deeper dye. This insect is the terror of horned cattle, horses, &c. Its mouth is armed with two sharp hooks which penetrate their hide; while with its proboscis, which is shaped like a sting, it sucks their blood, of which it is very greedy. The puncture of the tabanus is keen and painful. The insect is very common in damp woods and meadows, especially during the great heats, when it is most troublesome. The horned cat-

tle are sometimes so molested by their stings, that they go mad, run down precipices, tear themselves on the stumps of trees, stones, &c.

Tabarca,
Tabasheer.

2. The *pluviatilis* is of an ashen grey colour; its eyes are green, with brown streaks. The thorax is brown, marked with about seven longitudinal grey lines; the wings, which are brown and ash-coloured, are dotted over with small white spots, and have a black spot on the margin; the legs are surrounded with brown and white rings alternately. This species is very common in meadows, and is about four lines in length.

3. The *cæcutiens* has a brown head; eyes green and brown, with black spots; the thorax brown with black spots; the abdomen above, yellow with triangular brown spots; yellow legs, and white wings with black and brown spots. The length is four lines and a half.

TABARCA, a little island lying opposite to a small town of that name, which divides the maritime coasts of Tunis and Aigiers, in Africa, two miles from the land, in possession of the noble family of the Lamellini of Genoa, who have here a governor and a garrison of 200 men to protect the coral fishery. N. Lat. 36. 50 E. Long. 9. 16.

TABASHEER, a Persian word, signifying a hard substance found in the cavities of the bamboo or Indian reed, and highly valued as a medicine in the East Indies. Though some account was given of the tabasheer by the Arabian physicians, no accurate knowledge of it was obtained till Dr Russel favoured the public with his observations on it.

According to this gentleman's information, the tabasheer is produced from the female bamboo, which is distinguished from the male by the largeness of its cavity. It is easy to discover, without opening them, what bamboos contain it, as they make a rattling noise when shaken. Dr Russel having examined a bamboo brought from Vellore, consisting of six joints, found no appearance of tabasheer in two of them: all the rest contained some, but of various quality and quantity; the whole amounting to about 27 grains. The best was of a bluish white resembling small fragments of shells, harder also than the rest, but which might be easily crumbled between the fingers into a gritty powder; and when applied to the tongue and palate, had a slight saline and testaceous taste; the weight not exceeding four grains. The colour of the rest was cineritious, rough on the surface, and more friable; having some particles of a larger size intermixed, but light, spongy, and somewhat resembling pumice stones; which appearance, our author supposes, led the Arabians to think that fire was concerned in the production. The two middle joints were of a pure white colour within, and lined with a thin film. In these the tabasheer was principally found. The other joints, particularly the two upper ones, were discoloured within; and in some parts of the cavity was found a blackish substance in grains or in powder, adhering to the sides, the film being there obliterated.

Tabasheer In two or three of the joints a small round hole was found at top and bottom, which seemed to have been perforated by some insect.

||
**Taber-
nacle.**

Garzius informs us, that it is not found in all bamboos, nor in all the branches indiscriminately, but only in those growing about Bishnagur, Batecala, and one part of the Malabar coast. Dr Ruffel was informed by a letter from a medical gentleman attending the embassy to the Nizam, that though tabasheer bears a high price at Hyderabad, it is never brought thither from Bishnagur; and that some of what is sold in the markets comes from the pass of Atcour in Canoul; and some from Emnabad, at the distance of about 80 miles to the north west; but that the most part comes from Masulipatam. That sold in the markets is of two kinds; one the rate of a rupee *per dram*, but the other only half that price; the latter, however, is supposed to be factitious, and made up mostly of burnt teeth and bones. Dr Ruffel himself also, is persuaded that the tabasheer met with in commerce is greatly adulterated. The above-mentioned gentleman likewise informed the doctor that tabasheer was produced in great quantities at Sylhat, where it is sold by the pound, from one rupee to one and an half; forming a considerable article of trade from Bengal to Persia and Arabia. There is, however, a third kind, much superior to either of the two above described; differing not only in its superior whiteness, but likewise in being much less mixed with heterogeneous particles; being likewise much harder, heavier, and scarcely in any degree friable by the finger.

From the experiments of Dr Ruffel, it appears that the tabasheer is the juice of the bamboo thickened and hardened to a certain degree. Its chemical qualities, as far as we have heard, have not yet been minutely examined. The following observations on its medical effects were taken from a Persian work, intitled the "Tofut ul Monein of Mahommed Monein Hoseiny," by Mr Williams, a surgeon in the service of the East India company. The tabasheer puts a stop to bilious vomitings and to the bloody flux. It is also of service in cases of palpitation of the heart, in faintings, and for strengthening those members of the body that are weakened by heat. It is useful also for the piles, and for acute or burning fevers, and for pustules in the mouth (thrush); and, given with oxymel, is of service against restlessness, melancholy, and hypochondriacal affections. The habitual internal use of it is prejudicial to the virile powers. It is also said to be prejudicial to the lungs. Its correctives are the gum of the pine and honey. The dose of it is to the weight of two d'herems, or seven mathás.

TABBY, in commerce, a kind of rich silk which has undergone the operation of tabbying.

TABBYING, the passing a silk or stuff under a calendar, the rolls of which are made of iron or copper variously engraved, which bearing unequally on the stuff renders the surface thereof unequal, so as to reflect the rays of light differently, making the representation of waves thereon.

TABELLIO, in the Roman law, an officer or scrivener, much the same with our notaries-public, who are often called *tabelliones*.

TABERNACLE, among the Hebrews, a kind of building, in the form of a tent, set up, by express command of God, for the performance of religious worship, sacrifices, &c. during the journeying of the Israelites in the wilderness; and, after their settlement in the land of Canaan, made use of for the same purpose till the building of the temple of Jerusalem. It was divided into two parts; the one covered, and properly called the *tabernacle*; and the other open, called the *court*. The curtains which covered the tabernacle were made of linen, of several colours, embroidered. There were

ten curtains, twenty eight cubits long and four in breadth. Five curtains fastened together made up two coverings, which covered up all the tabernacle. Over these there were two other coverings; the one of goat's hair, the other of sheep's skins. The holy of holies was parted from the rest of the tabernacle by a curtain made fast to four pillars, standing ten cubits from the end. The length of the whole tabernacle was 32 cubits, that is, about 50 feet; and the breadth 12 cubits, or 19 feet. The court was a spot of ground 100 cubits long, and 50 in breadth, enclosed by 20 columns, each 20 cubits high and 10 in breadth, covered with silver, and standing on copper bases, five cubits distant from one another; between which there were curtains drawn, and fastened with hooks. At the east end was an entrance, 20 cubits wide, covered with a curtain hanging loose.

Feast of TABERNACLES, a solemn festival of the Hebrews, observed after harvest, on the 15th day of the month Tisri, instituted to commemorate the goodness of God, who protected the Israelites in the wilderness, and made them dwell in booths, when they came out of Egypt. On the first day of the feast, they began to erect booths of the boughs of trees, and in these they were obliged to continue seven days. The booths were placed in the open air, and were not to be covered with cloths, nor made too close by the thickness of the boughs; but so loose that the sun and the stars might be seen, and the rain descend through them. For further particulars of the celebration of this festival, see *LEVIT. ch. xxiii.*

TABERNÆ (anc. geog.) See *TRES Taberna.*

TABERNÆMONTANA, in botany: A genus of plants belonging to the class of *pentandria*, and order of *monogynia*; and in the natural system arranged under the 30th order, *Contortæ*. There are two horizontal foliioles, and the seeds are immersed in pulp. There are eight species, all of foreign growth.

TABLE, a moveable piece of furniture, usually made of wood or stone, and supported on pillars or the like, for the commodious reception of things placed thereon.

TABLE is also used for the fare or entertainment served up.

TABLE, in mathematics, systems of numbers calculated to be ready at hand for the expediting astronomical, geometrical, and other operations.

TABLE-Book. See *WRITING.*

TABLE-Mountain, a mountain of Africa, being the most westerly cape or promontory in that part of the world, and near the Cape of Good Hope. The bay which is formed thereby is called the *Table-bay*.

Laws of the Twelve TABLES, were the first set of laws of the Romans; thus called either because the Romans then wrote with a style on thin wooden tablets covered with wax; or rather, because they were engraved on tables or plates of copper, to be exposed in the most noted part of the public forum. After the expulsion of the kings, as the Romans were then without any fixed or certain system of law, at least had none ample enough to take in the various cases that might fall between particular persons, it was resolved to adopt the best and wisest laws of the Greeks. One Hermodorus was first appointed to translate them, and the decemviri afterwards compiled and reduced them into ten tables. After a world of care and application, they were at length enacted and confirmed by the senate and an assembly of the people, in the year of Rome 303. The following year they found something wanting therein, which they supplied from the laws of the former kings of Rome, and from certain customs which long use had authorised: all these being engraven on two other tables, made the law of the twelve tables, so famous in the Roman jurisprudence, the source and foundation of the civil or Roman law.

Taboo

Tacamahaca.

TABLES of the Law, in Jewish antiquity, two tables on which were written the decalogue, or ten commandments, given by God to Moses on mount Sinai.

TABOO, a word used by the South Sea islanders, nearly of the same import as prohibited or interdicted: It applies equally to persons and things, and is also expressive of any thing sacred, devoted, or eminent.

TABOR, a mountain of Galilee, about 12 miles from the city of Tiberias. It rises in the form of a sugar-loaf, in the midst of an extensive plain, to the height of 30 stadia, according to Josephus. The ascent is so easy, that one may ascend on horseback. On the top there is a plain two miles in circumference.

The situation of Mount Tabor is most delightful. Rising amidst the plains of Galilee, it exhibits to the enchanted eye a charming variety of prospects. On one side there are lakes, rivers, and a part of the Mediterranean; and on the other a chain of little hills, with small valleys, shaded by natural groves, and enriched by the hands of the husbandmen with a great number of useful productions. Here you behold an immensity of plains interspersed with hamlets, fortresses, and heaps of ruins; and there the eye delights to wander over the fields of Jezrael or Mageddon, named by the Arabs *Ebn-Aamer*, which signifies "the field of the sons of Aamer." A little farther you distinguish the mountains of Hermon, Gilboa, Samaria, and Arabia the Stony. In short, you experience all those sensations which are produced by a mixture and rapid succession of rural, gay, gloomy, and majestic objects.

It was upon this enchanting mount that the apostle Peter said to Christ, "It is good for us to be here: and let us make three tabernacles; one for thee, and one for Moses, and one for Elias."

Flavian Josephus, governor of Galilee, caused the summit of this mountain, for the space of two miles and a half, to be surrounded with walls. The inhabitants of Tabor long braved the power of the Roman armies; but being deprived of water in consequence of the great heats, they were forced to surrender at discretion to Placidus, the general of Vespasian.

Several churches were built upon this mountain by St Helen, who founded here also some monasteries. Of the two most remarkable, one was dedicated to Moses, and inhabited by Cenobites of the order of St Benedict, who followed the Latin rites: the other was dedicated to the prophet Elias by monks of the order of St Basil, attached to the Greek rites. The kings of Hungary erected here also a pretty spacious convent for some monks belonging to that nation, of the order of St Paul the first hermit. Tabor was also the seat of a bishop, dependant on the patriarchate of Jerusalem.

When Godfrey of Bouillon seized on this mountain, he repaired the ancient churches, which were beginning to fall into ruins. Under Baldwin I. in 1113, the Saracen troops retook Tabor; and their sanguinary fury gained as many victories as there were priests and Cenobites. This mountain again fell into the hands of the Christians; but the Catholic standard was not long displayed on it. Saladin pulled it down the year following, and destroyed all the churches. The Christians retook it once more in 1253; and their zeal made them rebuild all the sacred places. At this time Rome being accustomed to give away empires, Pope Alexander IV. granted Tabor to the Templars, who fortified it again. At length, in the course of the year 1290, the sultan of Egypt destroyed and laid waste the buildings of this mountain, which could never be repaired afterwards; so that at present it is uninhabited.

TACAMAHACA, in pharmacy, a solid resin, impro-

perly called a *gum* in the shops. It exudes from a species of poplar; and is in repute for mitigating pain and aches, and is also reckoned a vulnerary.

TACCA, in botany: A genus of plants belonging to the class of *dodecandria*, and order of *trigynia*. The flower is above. The corolla has six petals, and is vaulted. The calyx is hexaphyllous; the fruit a dry, angular, three-celled berry. There is only one species known, the *pinna-tifida*.

TACITUS (Caius Cornelius), a celebrated Roman historian, and one of the greatest men of his time, appears to have been born about the year of Rome 809 or 810, and applied himself early to the labours of the bar, in which he gained very considerable reputation. Having married the daughter of Agricola, the road to public honours was laid open to him in the reign of Vespasian; but during the sanguinary and capricious tyranny of Domitian, he, as well as his friend Pliny, appears to have retired from the theatre of public affairs. The reign of Nerva restored these luminaries of Roman literature to the metropolis, and we find Tacitus engaged, in the year 850, to pronounce the funeral oration of the venerable Virginius Rufus, the colleague of the emperor in the consulship, and afterwards succeeding him as consul for the remainder of the year.

The time of his death is not mentioned by any ancient author, but it is probable that he died in the reign of Trajan.

His works which still remain are, 1. Five books of his History. 2. His Annals. 3. A Treatise on the different Nations which in his time inhabited Germany: and, 4. The Life of Agricola his father-in-law. There is also attributed to him a Treatise on Eloquence, which others have ascribed to Quintilian. The Treatise on the Manners of the Germans was published in 851.—In the year 853, Pliny and Tacitus were appointed by the senate to plead the cause of the oppressed Africans against Marius Priscus, a corrupt proconsul, who was convicted before the fathers; and the patriot orators were honoured with a declaration that they had executed their trust to the entire satisfaction of the house. The exact time when Tacitus published his history is uncertain, but it was in some period of Trajan's reign, who died suddenly, A. U. C. 870, A. D. 117.—The history comprises a period of 27 years, from the accession of Galba, 822, to the death of Domitian, 849. The history being finished, he did not think he had completed the tabulation of slavery; he went back to the time of Tiberius: and the second work, which, however, comes first in the order of chronology, includes a period of 54 years, from the accession of Tiberius, 767, to the death of Nero, 821: this work is his "Annals."

It is remarkable, that princes and politicians have always held the works of Tacitus in the highest esteem; which look as if they either found their account in reading them, or were pleased to find courts, and the people who live in them, so exactly described after the life as they are in his writings. Part of what is extant was found in Germany, by a receiver of Pope Leo X. and published by Beroaldus at Rome in 1515. Leo was so much charmed with Tacitus, that he gave the receiver a reward of 500 crowns; and promised not only indulgences, but money also and honour, to any one who should find the other part; which it is said was afterwards brought to him. Pope Paul III. as Muretus relates, wore out his Tacitus by much reading; it; and Cosmo de Medicis, who was the first great duke of Tuscany, and formed for governing, accounted the reading of him his greatest pleasure. Muretus adds, that several princes, and privy-counsellors to princes, read him with great application, and regarded him as a sort of oracle in politics. A certain author relates, that Queen Christina of Sweden,

Tacca.
Tacitus.Murphy's
Translations
of Tacitus.Biographi-
cal Diction-
ary.Mariti's
Travels,
vol. ii.

Tacitus.
Baillet Vie
de Des
Cortes,
tom. ii.
Study of
History,
Letter v.

Sweden, though extremely fond of the Greek tongue, which she made "the diversion of her leisure hours, was not restrained by that from her serious studies; so she called among others Tacitus's History, some pages of which she read constantly every day." Lastly, our late Lord Bolingbroke, an authority surely of no mean rank, calls him, "a favourite author," and gives him manifestly the preference to all the Greek and Roman historians.

No author has obtained a more splendid reputation than Tacitus. He has been accounted, and with good reason, the most cultivated genius of antiquity; and we must not seek for his parallel in modern times. It is impossible not to admire and recommend his intimate knowledge of the human heart, the spirit of liberty which he breathes, and the force and vivacity with which he perpetually expresses himself. The reader of taste is struck by the greatness of his thoughts and the dignity of his narration; the philosopher by the comprehensive powers of his mind; and the politician by the sagacity with which he unfolds the springs of the most secret transactions. Civil liberty and the rights of mankind never met with a bolder or a more able assertor: servitude, debasement, and tyranny, appear not in the writings of any other author in juster or more odious colours. He has been censured as obscure; and indeed nothing can be more certain than that he did not write for the common mass of men. But to those who are judges of his compositions, it is no matter of regret that his manner is his own, and peculiar. Never were description and sentiment so wonderfully and so beautifully blended; and never were the actions and characters of men delineated with so much strength and precision. He has all the merits of other historians, without their defects. He possesses the distinctness of Xenophon without his uniformity; he is more eloquent than Livy, and is free from his superstition; and he has more knowledge and judgment than Polybius, without his affectation of reasoning on every occasion.

One of the best editions of the works of Tacitus was published at Paris by Brotier, in 4 vols 4to. There have been four translations of his works into English; the first by Greenway and Sir Henry Saville, in the reign of Elizabeth; the second by Dryden and others; the third by Gordon, which is remarkable for affectation of style, though

some think it bears a striking resemblance to the original; and the fourth and best by Murphy, in 1793, in 4 vols 4to.

TACK, a rope used to confine the foremost lower corners of the courses and stay-sails in a fixed position, when the wind crosses the ship's course obliquely. The same name is also given to the rope employed to pull out the lower corner of a studding-sail or driver to the extremity of its boom.

The main-sail and fore-sail of a ship are furnished with a tack on each side, which is formed of a thick rope tapering to the end, and having a knot wrought upon the largest end, by which it is firmly retained in the clue of the sail. By this means one tack is always fastened to windward, at the same time that the sheet extends the sail to the leeward.

TACK, is also applied, by analogy, to that part of any sail to which the tack is usually fastened.

A ship is said to be on the starboard or larboard tack, when she is close-hauled, with the wind upon the starboard or larboard side; and in this sense the distance which she sails in that position is considered as the length of the tack; although this is more frequently called *board*. See that article.

To TACK, to change the course from one board to another, or turn the ship about from the starboard to the larboard tack, in a contrary wind. Thus a ship being close-hauled on the larboard tack, and turning her prow suddenly to windward, receives the impression of the wind on her head-sails, by which she falls off upon the line of the starboard-tack. Tacking is also used in a more enlarged sense, to imply that manœuvre in navigation by which a ship makes an oblique progression to the windward, in a zig-zag direction. This, however, is more usually called *beating*, or *turning to windward*. See **NAVIGATION**, **SAILING**, and **Naval TACTICS**.

TACK, in Scots law. See **LAW**, n° clxvii.

TACKLE, among seamen, denotes all the ropes or cordage of a ship used in managing the sails, &c.

TACKSMAN. See **TENURE**.

TACTICS, in the art of war, is the method of disposing forces to the best advantage in order of battle, and of performing the several military motions and evolutions. See **WAR**.

NAVAL TACTICS;

Or, The Military Operations of Fleets.

Definition.

NAVAL TACTICS is the art of ranging fleets in such order or disposition, as may be judged most convenient, either for attacking, defending, or retreating, to the greatest advantage; and to regulate their several movements accordingly. It is not a science established on principles absolutely invariable, but founded on such reasons as the alteration and improvement of arms must necessarily occasion in a course of time and experience; from which also will naturally result a difference in the construction of ships, in the manner of working them, and, in fine, in the total disposition and regulation of fleets and squadrons. We shall cursorily run through this succession and change of arms, &c. to the present improvement of our lines of battle, in order to make us the more sensible of the reasons which have induced the moderns to prefer so advantageous a choice as they now follow in the arrangement of their ships.

History.

The ancient galleys were so constructed as to carry several banks of oars, very differently disposed from those in our modern galleys, which, however, vary the least of any others from their ancient model. Advanced by the force of their oars, the galleys ran violently aboard of each other,

and by the mutual encounter of their beaks and prows, and sometimes of their sterns, endeavoured to dash in pieces, or sink their enemies.

The prow, for this purpose, was commonly armed with a brazen point or trident, nearly as low as the surface of the sea, in order to pierce the enemy's ships under the water. Some of the galleys were furnished with large turrets, and other accessions of building, either for attack or defence. The soldiers also annoyed their enemies with darts and slings, and, on their nearer approach, with swords and javelins; and in order that their missile weapons might be directed with greater force and certainty, the ships were equipped with several platforms, or elevations above the level of the deck. The sides of the ship were fortified with a thick fence of hides, which served to repel the darts of their adversaries, and to cover their own soldiers, who thereby annoyed the enemy with greater security.

As the invention of gunpowder has rendered useless many of the machines employed in the naval wars of the ancients, the great distance of time has also consigned many of them to oblivion: some few are, nevertheless, recorded in ancient authors,

Tack
Tactics.

Falconer's
Marine
Dictionary.

History. authors, of which we shall endeavour to present a short description. And first,

The *Δελφιν* was a large and mazy piece of lead or iron, cast in the form of a dolphin. This machine being suspended by blocks at their mast-heads or yard-arms, ready for a proper occasion, was let down violently from thence into the adverse ships; and either penetrated through their bottom, and opened a passage for the entering waters, or by its weight immediately sunk the vessel.

The *Δρεπανον* was an engine of iron crooked like a sickle, and fixed on the top of a long pole. It was employed to cut asunder the slings of the sail-yards, and, thereby letting the sails fall down, to disable the vessel from escaping, and incommode her greatly during the action. Similar to this was another instrument, armed at the head with a broad two-edged blade of iron, wherewith they usually cut away the ropes that fastened the rudder to the vessel.

Δορὰν ναυμαχικὰ, a sort of spears or maces of an extraordinary length, sometimes exceeding 20 cubits, as appears by the 15th Iliad of Homer, by whom they are also called *μακρὰ*.

Κατακλι were certain machines used to throw large stones into the enemy's ships.

Vegetius mentions another engine which was suspended to the main-mast, and resembled a battering-ram; for it consisted of a long beam and an head of iron, and was with great violence pushed against the sides of the enemy's galleys.

They had also a grappling-iron, which was usually thrown into the adverse ship by means of an engine: this instrument facilitated the entrance of the soldiers appointed to board, which was done by means of wooden bridges, that were generally kept ready for this purpose in the fore-part of the vessel. See the article CORVUS.

The arms used by the ancients rendered the disposition of their fleets very different, according to the time, place, and circumstances of the engagement. They generally considered it an advantage to be to windward, and to have the sun shining directly on the front of their enemy. The order of battle chiefly depended on their power of managing the ships, or of drawing them readily into form; and on the schemes which their officers had concerted. The fleet being composed of rowing vessels, they lowered their sails previous to the action; they presented their prows to the enemy, and advanced against each other by the force of their oars. Before they joined battle, the admirals went from ship to ship, and exhorted their soldiers to behave gallantly. All things being in readiness, the signal was displayed by hanging out of the admiral's galley a gilded shield, or a red garment or banner. During the elevation of this, the action continued; and by its depression, or inclination towards the right or left, the rest of the ships were directed how to attack or retreat from their enemies. To this was added the sound of trumpets; which began in the admiral's galley, and continued round the whole fleet. The fight was also begun by the admiral's galley, by grappling, boarding, and endeavouring to overset, sink, or destroy the adversary, as we have above described. Sometimes, for want of grappling-irons, they fixed their oars in such a manner as to hinder the enemy from retreating. If they could not manage their oars as dexterously as their antagonist, or fall alongside so as to board him, they penetrated his vessel with the brazen prow. The vessels approached each other as well as their circumstances would permit, and the soldiers were obliged to fight hand to hand till the battle was decided: nor indeed could they fight otherwise with any certainty, since the shortest distance rendered their slings and arrows, and almost all their offensive weapons, ineffectual, if not useless. The squadrons were sometimes ranged in two or

three right lines, parallel to each other; being seldom drawn up in one line, unless when formed into an half-moon. This order indeed appears to be the most convenient for rowing vessels, that engage by advancing with their prows towards the enemy. At the battle of Ecnomus, between the Romans and the Carthaginians, the fleet of the former was ranged into a triangle, or a sort of wedge in front, and towards the middle of its depth of two right parallel lines. That of the latter was formed into a rectangle, or two sides of a square, of which one branch extended behind, and as the opening of the other prosecuted the attack, was ready to fall upon the flank of such of the Roman galleys as should attempt to break their line. Ancient history has preserved many of these orders, of which some have been followed in later times. Thus, in a battle A. D. 1340, the English fleet was formed in two lines, the first of which contained the larger ships, the second consisted of all the smaller vessels, used as a reserve to support the former whenever necessary. In 1545, the French fleet under the command of the Marechal d'Annebault, in an engagement with the English in the Channel, was arranged in the form of a crescent. The whole of it was divided into three bodies, the centre being composed of 36 ships, and each of the wings of 30. He had also many galleys; but these fell not into the line, being designed to attack the enemy occasionally. This last disposition was continued down to the reigns of James I. and Louis XIII.

Meanwhile, the invention of gunpowder in 1330 gradually introduced the use of fire-arms into naval war, without finally superseding the ancient method of engagement. The Spaniards were armed with cannon in a sea-fight against the English and the people of Poitou abreast of Rochelle in 1372; and this battle is the first wherein mention is made of artillery in our navies. Many years elapsed before the marine armaments were sufficiently provided with fire-arms. So great a revolution in the manner of fighting, and which necessarily introduced a total change in the construction of ships, could not be suddenly effected. In short, the squadrons of men of war are no longer formed of rowing vessels, or composed of galleys and ships of the line; but entirely of the latter, which engage under sail, and discharge the whole force of their artillery from their sides. Accordingly, they are now disposed in no other form than that of a right line parallel to the enemy; every ship keeping close-hauled upon a wind on the same tack. Indeed the difference between the force and manner of fighting of ships and galleys, rendered their service in the same line incompatible. When we consider therefore the change introduced, both in the construction and working of the ships, occasioned by the use of cannon, it necessarily follows, that squadrons of men of war must appear in the order that is now generally adopted.

The machines which owe their rise to the invention of gunpowder have now totally supplanted the others; so that there is scarce any but the sword remaining, of all the weapons used by the ancients. Our naval battles are therefore almost always decided by fire-arms, of which there are several kinds, known by the general name of *artillery*. In a ship of war, fire-arms are distinguished into cannon mounted on carriages (swivel-cannon, grenadoes, and musquetry. See CANNON, &c. Besides these machines, there are several others used in merchant ships and privateers, as cohorns, carabines, fire-arrows, organs, flink pots, &c.

The writers on naval tactics have been but few, indeed, considering the importance of the subject; and the only countries that have produced writers on this subject, so far as we know, are France and Britain, particularly the first. One would be led to imagine that Britain, from its insular situation, having bred so great a number of excellent seamen, and

History.

^{History.} and having so often been engaged in naval contests, would naturally have produced a number of writers on this, as well as on subjects of much less consequence to it as a nation. The reader will, however, no doubt be surprised to hear, that we have only one scientific treatise on naval tactics, intitled *An Essay on Naval Tactics, &c.* by John Clerk, Esq; of Eldon, near Edinburgh; all the other treatises published in Britain on this subject being either translations from the French, or remarks upon the French authors (A). Some of the principal French treatises on naval tactics are the following: 1. *L'Art des Armées Navales, ou Traité des Evolutions Navales*, par Paul L'Hôte, 1 vol. folio, printed at Lyons 1727. This book was translated and published by Christopher O'Bryen, Esq; in 4to, in 1762. 2. *Tactique Navale, ou Traité des Evolutions et des Signaux*, par M. le Viscompte de Morogues, 4to, Paris 1763. 3. *Le Manœuvrier*, par M. Bourdè de Vilhuet. 4. *L'Art de Guerre en Mer, ou Tactique Navale, &c.* par M. le Viscompte

^{History.} de Grenier. Translations of the two last have appeared in English in 4to in 1788, under the name of the *Chevalier de Saufeul*; and a translation of parts of the three last is in the 2d vol. of the *Elements and Practice of Rigging and Seamanship*, published at London in 1794. Other books on evolutions and tactics are, *Théorie de la Manœuvre des Vaisseaux*, Paris, 1689. *Pitot's Theory of Working Ships applied to Practice &c.* translated by Stone, 1743. *De la Manœuvre des Vaisseaux, ou Traité de Mécanique et de Dynamique, &c.* par M. Bouguer. *The British Mars, &c.* by William Flexney, 1763. *A Sea Manual*, by Sir Alexander Schomberg, 1789. *A View of the Naval Force of Great Britain, &c.* by an Officer of Rank, 1791, &c.

We shall occasionally consult all these works; and as some of them treat largely of the tactics in present use, while in others new systems are proposed, our article will naturally be divided into two parts, keeping the present practice and proposed innovations totally distinct from each other.

PART I. THE PRESENT SYSTEM OF NAVAL TACTICS.

CHAP. I. Of the Orders of Sailing.

³
Division of
a fleet into
three squa-
drons, the
van, centre,
and rear.

A FLEET of ships of war is usually divided into three divisions or squadrons, called the *centre, van, and rear*; and each squadron has a commanding officer. The commander in chief, or admiral of the fleet, is in the centre column; the vice-admiral has the command of the van; and the rear admiral, that of the rear. The ships of each squadron are distinguished by the position of their colours. The ships of the first or centre squadron carry their pendants at the main-top-gallant mast head. The ships of the second division carry their pendants at the fore top-gallant mast head, and those of the third division at the mizen-top mast head. Each squadron ought, if possible, to consist of the same number of ships; and also to be of the same force, so that each may be equally able to attack or repulse the enemy; and when in a line, the several parts will be equally strong. When the fleet is very numerous, each squadron is sometimes subdivided in a similar manner into three divisions of centre, van, and rear.

When the fleet is formed in the line or order of battle, each admiral takes his post in the centre of his squadron, the commander in chief being in the middle of the line. If the enemy be not in fight, the store-ships, fire-ships, sloops, &c. are to be to the windward of the fleet, because they can be more easily supported, and can more readily obey the signals that may be made to them. There are frigates to the windward of the van and rear of the convoy, for the purpose of looking out for the enemy, and keeping those vessels in their proper stations. But if the enemy is in fight, then all those ships which are not to be in the line of battle are to be on the other side of the line with respect to the enemy. If the fleet is sailing in three columns, the first or centre squadron is in the middle between the second and third squadrons; one of which, according to circumstances, forms the starboard and the other the larboard column: and each admiral leads his respective division. If the fleet is destined for a certain place at a considerable distance, it is generally formed into squadrons; but if cruising in expect-

tation of meeting the enemy, the admiral naturally keeps his ships in such sailing positions as may be most advantageous to form for action as quickly as possible. These various positions or arrangements are called *orders*; and that they may be better understood, it is necessary to premise the following definitions:

⁴
The starboard line of bearing, is that line upon which the ships of a fleet, being ranged, bear from each other upon a close-hauled line, whatever course they may be steering; and so that, upon hauling their wind or tacking together as may be necessary, the ships will be in a line close-hauled upon the starboard tack.

⁵
The larboard line of bearing, is that line from which the ships of the fleet, by hauling their wind, or tacking together, may be formed in a line close-hauled on the larboard tack.

⁶
A fleet of ships is said to be in the *line abreast* when the ships keels are parallel to each other, and their mainmasts in the same straight line.

⁷
The bow and quarter line, is when the ships are ranged in a straight line cutting their heels obliquely in the same angle: Hence at any intermediate ship, the ships towards one extremity of the line will be on the bow, and those towards the other extremity will be on the quarter, of that ship.

⁸
If several ships stand on the same line and steer the same course, but different from that line, they are said to be in *echiquier*, or *chequerwise*.

⁹
Manœuvre in succession, is when a fleet, ranged in one of the orders of sailing, and standing on the same line, the same manœuvre is successively performed by each ship as she arrives at the wake of the van ship of the whole fleet, if in one line; or of the van ship of her particular division when divided into squadrons. So that a fleet tacks or veers, bears away or comes to the wind in succession, when all the ships of every line execute, one after another, the same manœuvre on the same point of the wake of the leading ship.

¹⁰
The number of orders of sailing is commonly assumed to be five; and denominated the *first, second, third, fourth, and fifth* orders of sailing; besides an order of *battle*, an order of *retreat*, &c.

In

(A) The reason why Britain falls short of the French in this respect, is, that in various sea-ports in France there are academies established for the express purpose of educating those intended for the navy in the various branches of naval science; whereas, in Britain, there is only one academy established at the expence of government, namely, the Marine Academy at Portsmouth; and, excepting navigation, scarcely any other branch of naval science is taught in that seminary. It also requires great interest to be admitted. We are, indeed, well aware that there are boys educated for the sea-service in Christ's Hospital, London, and at Greenwich school, &c. The education there is not, however, adapted for officers in the navy, being only writing, arithmetic, a little mathematics necessary to understand navigation, and navigation.

Orders of
Sailing.
Plate
cccxciii,
11
First order
of sailing.

In the first order of sailing, the fleet is ranged on one of the lines of bearing, and each ship steering the same course. Thus, in fig. 1. let the wind be north, and the fleet ranged on the starboard line of bearing, and let the ships steer any course, as south-west. In this case, the fleet is ready to form the line on the starboard tack by hauling the wind. Again, let the fleet be ranged on the larboard line of bearing, and steering the same course as before, as in fig. 2.; then the fleet is in a position ready to form the line on the larboard tack, by tacking.

In a numerous fleet this method of sailing is defective; as the fleet will be too much extended, and therefore the communication between the van and the rear rendered more difficult than when in a more connected order. It is of use, however, when the enemy is in sight, as then the fleet may be readily formed in order of battle; and in that case only, or in passing through a strait, will it be necessary to range the fleet in this order.

12
Second order of sailing.
In the second order of sailing the fleet is ranged on a line perpendicular to the direction of the wind, and steering any proper course. This order, which is represented in fig. 3. has the same defects as the former; and has also this disadvantage attending it, that the fleet cannot safely tack in succession from this order, as each ship at the time of tacking is in danger of falling on board the ship next astern; and therefore, if the line is close, the ship astern must bear up considerably, in order to avoid being on board the ship ahead, which at that time is in stays.

13
Third order of sailing.
The third order of sailing is that in which the whole fleet is close-hauled, ranged upon the two lines or lines of bearing, and therefore containing an angle of twelve points; the admiral's ship being at the angular point, and the whole fleet steering the same course. Thus, in fig. 4. the wind being supposed north, and the fleet close-hauled on the starboard tack: Then A being the admiral's ship, one part of the fleet bears from him west-north-west, and the other part east-north-east.

This order of sailing is no doubt preferable to either of the former, as the ships are more collected, and can more distinctly perceive and obey the signals; but if the fleet is numerous, it will be too much extended.

14
Fourth order of sailing.
In the fourth order of sailing, the fleet is divided into six or more columns, as may be judged necessary: by which means the fleet is much more connected than in any of the former orders. The commanders, ranged upon the two lines of bearing, have their squadrons astern of them upon two lines parallel to the direction of the wind; the first ships of each column being, with respect to the commander of their squadron, the one on his starboard and the other on his larboard quarter. The distance between the columns should, however, be such, that the fleet may readily reduce itself to the third order of sailing, and from that to the order of battle. This order is adapted for fleets or convoys crossing the ocean, and is represented in fig. 5. But as it requires much time to reduce a fleet from this order to that of battle, it is therefore defective when in presence of an enemy.

15
Fifth order of sailing.
The fifth and last order of sailing is that in which the fleet is divided into three columns close-hauled, and therefore parallel to each other; and also the respective ships abreast of each other. The van commonly forms the weather column; the centre division, the middle column; and the rear division, the lee column. Circumstances may however require the van to be the lee column, and the rear the weather column. If the fleet is very numerous, each division may be divided into two columns; and each admiral is to place himself at a little distance before, and in the direction of the middle of his division. Fig. 6. and 7. represent this order of sailing.

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The distance between any ship and that adjacent to it in the same column, and also the interval between the columns, are regulated by the commander in chief according to circumstances. The interval or perpendicular distance between the columns is commonly taken; such as, that the angle contained between the line of the columns and an imaginary line joining one of the extreme ships of that column, and the ship at the other extremity of the adjacent column, may be about two points. The measure of this angle must however depend in part upon the length of the column; and when it is determined upon, the distance between the columns may be found by multiplying the length of one of the columns by the tangent of the above angle to the radius unity: whence, if that angle be taken equal to two points, the length of a column multiplied by the decimal .414 will give the distance between the columns. Thus let a column contain six ships; let the distance between each be 100 fathoms; and the length of each ship from the extremity of the bowsprit to the stern 46 fathoms; then the whole length of the column will be 776 fathoms. Now the above angle being taken equal to two points, the distance between the columns is equal to $776 \times .414 = 321\frac{1}{4}$ fathoms.

17
Order of battle.
The order of battle is formed by drawing up the ships of the fleet in a line nearly close-hauled, and under an easy sail; each ship being at a certain assigned distance from that next ahead, as a half or a whole cable's length. The fire-ships, with frigates ahead and astern, form a line parallel to the former, and to the windward of it if the enemy is to the leeward; but to the leeward if the enemy is to the windward. Without this line another is formed, parallel thereto, of the store-ships, &c. with frigates ahead and astern. Fig. 8. represents the order of battle, the fleet being on the starboard tack.

18
Order of retreat.
In retreating from a superior force, it is necessary to draw up the fleet in such an order that it may, with the greatest advantage, oppose or annoy the fast sailing vessels of the enemy: for this purpose, the order of retreat commonly taken is that which is the inverse of the third order of sailing. As the fleet generally runs before the wind, the ships of the line are therefore ranged on the two lines of bearing; hence these lines contain an angle equal to 135 degrees. The admiral is at the angular point, and the frigates, transports, &c. are included within the wings to leeward. In place of running before the wind, the fleet may take any other proper direction; but still the angle contained by the wings is to be 135°. This order of retreat is represented in fig. 9.

19
Order of convoy.
The order of convoy is that in which the ships are all in the wake of one another, steering on the same point of the compass, and forming a right line. If the fleet is numerous, it may be divided into three columns, which are to be ranged parallel to each other, that of the admiral occupying the middle, and all steering the same course.

Having defined the different orders of sailing, we shall now proceed to show the method of getting a fleet under way, and of bringing it to an anchor.

20
To get a fleet under way.
In order to get a fleet under way, the lee column is to get under way first, and bring to all at the same time, just as they find themselves after casting. The centre column is then to perform the same manoeuvre, and cast likewise as soon as the other column is brought to; and both columns will remain in that position till the weather column, which is still apeak, having weighed, shall be also under way. The three columns may often be got under way all at once: but to execute this the fleet must all act together, and with equal ardour; for the weather ships must not, at any rate, be under way before the lee ones. If it be necessary to get immediately in order of battle, the weather columns are at once to bear away two points together, that they may take their posts in the line of battle ahead of the lee column.

M m

If

Orders of
Sailing.

If the fleet be moored in a line, head to wind, the rear ship may get under way first, and haul immediately by the wind; the others in succession, from the rear to the van, can easily take their station in her wake, so that the rear ship will now become the leader. Or, the fleet may all get under way at the same time; but the van ship is to bring to, while the rest, casting the other way, would stand on by the wind on the same tack on which they have cast, and come to tack successively in her wake, to form the order of battle.

21
To bring a
fleet to an
anchor.

To bring a fleet to an anchor, it ought, if considerable, to anchor in three parallel lines, on one of the lines of bearing, and at the proper distance which the length of the columns require; the distance between the adjacent ships in the same column being about a cable's length. The van and rear of the columns are to correspond with each other exactly in the direction of the wind, that they may with ease get under way, and form the order of battle with facility, so as to be able to dispute the weather-gage with the enemy if he should come in sight. As this evolution is to be performed in moderate weather, the fleet being in three columns, they are all at the same time to bring their ship's head to the wind under their topsails, and let go their anchors together, clewing up their topsails with all possible dispatch; putting the foot of the sails in the tops, and loosening the sheets before hauling them down; then veering away an equal quantity of cable to preserve the assigned distance. When it blows so fresh as to require the topsails being reefed, two cables length may be kept between the ships, and even three if it be likely to blow hard.

If the fleet do not exceed 20 ships, they may anchor on one of the lines of bearing; or parallel to the coast, in places where trade-winds are common, provided they blow in the direction of the land; for, in all cases, they must be in a condition to get under way at the first sight of the enemy, whose approach is never to be waited for at anchor; because, if it be dangerous for a single ship, it must be still more so for a fleet, the movements of which are interrupted by the difficulty there is in getting with celerity under way ships which are moored, and which, in that case, are not able mutually to support one another, as is absolutely requisite in a fleet.

CHAP. II. *The Manner of Forming the several Orders of Sailing.*

22
To form
the first
order of
sailing.

THE first order of sailing is formed as follows: As the fleet is supposed to be in no particular order, that ship which is to lead on the proposed line of bearing on which the fleet is to sail, runs to the leeward of the whole or greater part of the fleet, and then hauls her wind, carrying an easy sail: each ship then endeavours to get into her proper station, by chasing the ship which is to be next ahead of her; and when in the wake of the leader, must take care to preserve the assigned distance from the ship immediately ahead, by increasing or diminishing the quantity of sail: and if any of the fleet should happen to be so far removed from her second ahead as not to be able to chase her without getting out of her way towards the line, in that case she must take her station discretionally in a line with the leaders, and leave a proper interval. The fleet will now be formed in the line of battle; from which the first order of sailing is formed by each ship bearing away at the same instant, and steering each the same proposed course.

23
To form
the second
order of
sailing.

To form the second order of sailing, the leader runs to the leeward of the whole, or of so many of the fleet as that each ship may easily fetch his wake, and then steers a course eight points from the wind, carrying an easy sail. Each

ship now gets into her proper station, by chasing that which is to be ahead of her; and when the whole fleet is formed in a line, which will be perpendicular to the direction of the wind, each ship bears away at the same instant, and the whole steer the same intended course.

In the third order of sailing the admiral is in the middle of his fleet. Now, the fleet being formed in a line, on one of the lines of bearing, as above directed, and the ships steering in the wakes of each other, or ten points from the wind, the leading or leewardmost ship first hauls her wind; the second ship, as soon as she is in the wake of the leader, hauls her wind also; and in like manner each ship until the admirals successively haul their wind as soon as they have reached the wake of the leading ship; and at the same instant that the admiral's ship hauls her wind, the other, or sternmost half of the fleet, do the same. The fleet will then be in the third order of sailing, as represented in fig. 4. From this order of sailing the fleet can be expeditiously formed into the line of battle on either tack.

As the fleet, in the fourth order of sailing, is divided into six columns, and the three commanders ranged on the two lines of bearing, the commander in chief being at the angular point; in order, therefore, to form this order, the admirals range themselves on the two lines of bearing, at a proper distance from each other, and steer the proper course; the ships of the several columns come each into its respective place, forming themselves into lines in the direction of the wind, and parallel to each other, as in fig. 5.

In order to form the fifth order of sailing, the three leading ships of the divisions are to take their posts abreast, and to leeward of each other, keeping their wind under an easy sail. Then the ships of each squadron making sail, will range themselves in their respective stations, astern of their leaders, and keeping the same course; each ship preserving the appointed distance from that next ahead; and the commanders of each division, and each second, third, &c. ship, are to keep themselves mutually abreast of each other.

To form the order of battle, it has already been observed, in the first order of sailing, that the ship which is to lead runs to the leeward of the whole, and then hauls her wind upon the tack directed, carrying an easy sail. Each ship then makes sail according to her distance, and chases the ship which is to be immediately ahead of her in the line, and hauls in her wake in the line on which the van ship is moving.

The admiral, or ship appointed to make the angular point, runs to the leeward of the fleet, and brings to; then each ship runs to its respective station in one of the lines of bearing, and brings to; one half of the fleet being on one of the lines of bearing, astern and in the wake of the admiral, and the other half on the other line of bearing, on the starboard or larboard bow of the admiral. When this is accomplished, the whole fleet bears away before the wind: the two wings will now bear from the admiral two points before his beam, and ready to form the line of battle upon either tack; the ships on the admiral's starboard bow being in the line of bearing for the larboard tack, and those on his larboard bow in the line of bearing for the starboard tack.

CHAP. III. *To Change from the several Orders of Sailing to the Line of Battle.*

To form the line from the first order of sailing: If the ships be running large on the tack answering to the line of bearing on which they are sailing and the line to be formed on the same tack, all the ships haul the wind at the same time, or at least each ship hauls her wind immediately after the next to windward: but if the fleet be on the other tack with

Manner of
Forming
the several
Orders of
Sailing.

24
To form
the third
order of
sailing.

25
To form
the fourth
order of
sailing.

26
To form
the fifth
order of
sailing.

27
To form
the order
of battle.

28
To form
the order
of retreat.

29
To form
the line of
battle from
the first or
der of sail-
ing.

To change from the Orders of Sailing to the Line of Battle.

Plate cccxciv.
30

From the second order of sailing.

31
From the third order of sailing.

32
From the fifth order of sailing.

33
The centre and weather columns interchanging.

34
The centre and lee columns interchanging.

with respect to the line of bearing, all the ships haul their wind and tack together, or all veer together according to circumstances. If the line of battle is to be formed on the other line of bearing, the leewardmost ship either veers or tacks, and hauls her wind: the rest of the fleet veer or tack at the same time, and steer with the wind four points free; and each ship successively, as soon as she gets into the wake of the leader, hauls her wind. Hence the line of battle will be formed from the first order of sailing. See figs. 10. and 11.

To form the line from the second order of sailing, the fleet running large or before the wind: All the ships of the fleet haul up together on the tack directed, presenting their heads on the line upon which they are ranged, or eight points from the wind. The leading ship then hauls her wind, and is followed in succession by the rest. That the ships may not be too near each other, they make fail as they haul their wind, or their seconds aftern shorten fail to open the order. See fig. 12.

To change from the third order of sailing to the line of battle: The ships being supposed going large, that wing which is in the line of bearing for the tack on which the line is to be formed, and the ship at the angular point, haul their wind at the same time; the ships of the other wing haul up together eight points from the wind; then each ship moves in this direction until she reaches the wake of the other wing, where she hauls close up. See fig. 13.

To form the line of battle on the same tack from the fifth order of sailing: Let the weather column form the van, and the lee column the rear. The centre brings to, or only keeps steerage-way; the weather-column bears away two points, and hauls its wind as soon as it is ahead of the centre; the lee-column tacks together, and runs under a press of sail, to gain the wake of the centre, when it retacks together and completes the line (see fig. 14.) This evolution may also be performed as follows: The weather-column brings to; the centre and lee columns tack together, and go away two points free: when the centre-column has gained the wake of the van, it retacks together, and brings to; and when the lee column has gained the rear-line, it retacks together, and then all stand on: otherwise the lee-column brings to; the centre goes under an easy fail two points free, to get ahead of the rear-squadron; while the van carries a press of sail, also two points free, to get ahead of the centre divisions.

Hitherto the weather column has uniformly been supposed to form the van, and the lee-column the rear-division: the line may, however, be formed by interchanging these columns in a variety of different ways, some of which are as follow.

1. Let the weather and centre columns interchange: In this case the centre-column stands on, the weather-column bears away eight points, and as soon as it reaches the wake of the centre-column, which now forms the van, hauls up together: the lee-column tacks together, and goes under a press of sail scarcely two points free, so as just to gain the rear of the line, and then retacks together, as in fig. 15. This evolution may also be performed by the lee column bringing to; the centre squadron then bears away together one point, and as soon as it has gained the head of the line, hauls its wind; and the weather column bears away together three points, under an easy fail; and when it has got into the wake of the van, hauls up together, forming the centre division.

2. Let the centre and lee columns interchange: The lee-column stands on close-hauled, under an easy fail; the weather-column bears away two points under a press of sail, until it reaches the head of the line, and then hauls up: the centre-

column bears away eight points; and when in the wake of the lee-column, which is now the centre division, hauls its wind. See fig. 16.

3. The weather and lee columns interchanging: For this purpose, the lee-column stands on close-hauled under a press of sail; the centre-column bears away two points under an easy fail, and hauls up as soon as it has come into the wake of the new van squadron; and the weather-column bears away eight points until it gains the wake of the centre-column, and then hauls up, as in fig. 17.

4. The centre forming the van, and the weather column the rear-division: The lee-column brings to, the centre-column bears away together two points, and forms the line ahead of the new centre squadron; the weather-column veers away together seven points on the other tack, and forms the rear squadron. See fig. 18.

5. The lee-column to form the van, and the centre the rear division: In order to this, the lee-column stands on under a press of sail, the weather-column bears away together three points under an easy fail, and the centre column bears away eight points; and each, when it has gained the wake of the new van, hauls its wind. See fig. 19.

To form the line of battle on the other tack from the fifth order of sailing. The weather-column first tacks in succession; the centre and lee columns stand on, the first under an easy fail, and the second under still less fail, according to the length of the columns; and the leaders tack when they gain the wake of the new-formed van, and each ship tacks in succession as it reaches the wake of the above mentioned van (see fig. 20.) Very great care must be taken by the centre and lee columns, lest they draw too near the sternmost ships of the van, and also each other.

To perform this evolution, the centre and weather columns interchanging: The weather column brings to, the centre column stands on until the leader judges he will be fully able to clear the weather-column, and then the centre-column tacks in succession: when the last ship of this new-formed van has passed the weather column, that column stands on, and each ship tacks in succession as soon as it reaches the wake of the van. The lee-column stands on, and tacks in succession as the ships attain the wake of the van, and at the same time carrying a moderate fail, that there may be a sufficient interval left for the weather-column to form the centre division. See fig. 21.

To form the line from the fifth order of sailing on the other tack, the centre and lee columns interchanging. The centre-column brings to; the weather-column tacks in succession under very little fail, and the lee-column stands on under a press of sail: when the leader of the lee-column has gained the wake of the line, he tacks, and is followed in succession by his division. The centre-column is to fill and stand on, when the first ship of that column, and the last ship of the lee-column, bear from each other in a line perpendicular to the direction of the wind. See fig. 22.

To form the line on the other tack from the fifth order of sailing, the weather and lee columns interchanging: The weather and centre columns bring to; the lee-column stands on under a press of sail, until it can pass ahead of the weather-column, and then tacks in succession; the centre-column fills where its leading ship and the last ship of the lee-column bear from each other, in a line perpendicular to the direction of the wind, and tacks in succession when it has gained the wake of the new van. In like manner, the weather-column fills when its leading ship and the last of the centre bear in a line perpendicular to the wind, and each ship tacks in succession when it has gained the wake of the centre. See fig. 23.

To form the line on the other tack, the centre forming the

To change from the Line of Battle to the Orders of Sailing.

43 The lee-column passing to the van.

44 To form the line from the order of retreat.

45 To change from the line of battle to the first order of sailing.

46 To change to the second order of sailing.

47 To change to the third order of sailing.

Plate cccxcvi.

48 To change to the fifth order of sailing on the same tack.

the van, and the weather the rear division: The weather-column brings to, the other columns make sail and stand on, till they can pass on the other tack ahead of the weather-column, when they tack in succession. When both columns have passed the weather column, it fills, tacks in succession, and forms the rear. See fig. 24.

To form the line on the other tack from the fifth order of sailing, the lee-column forming the van: The weather and centre columns bring to; the lee-column carries a press of sail, and tacks in succession when it can pass ahead of the weather-column; and when the last ship of this new van has passed to the windward of the former weather-column, the van squadron shortens sail, to give time for the other columns to form: the weather and centre columns fill at the same time, to gain the wake of the van, when they tack in succession. See fig. 25.

To form the line from the order of retreat: The leader of the wing, which is to form the head of the line, hauls the wind, and that wing follows in succession; the other wing goes four points free together on the same tack, and thus runs parallel to the wing which first began the evolution; and they haul up together when they arrive in the wake of the line. See fig. 26.

CHAP. IV. To change from the Line of Battle to the different Orders of Sailing.

To change from the line of battle to the first order of sailing on the same tack: All the ships bear away together the number of points directed by the admiral, observing to keep themselves in the line of bearing for the tack they are in. The sternmost ship bears away first, and the rest successively as quickly as possible, to prevent being too near each other.

To change to the first order of sailing in bearing for the line on the other tack: The leader bears away four points to leeward, and is followed in succession by the rest. When the sternmost ship has bore away, the whole haul up, and they will be in bearing for the line on the other tack. See fig. 27.

To change from the line of battle to the second order of sailing: The whole fleet bears away together ten points; and so proportions the sailing from the van to the rear of the line, that when the headmost ship, which first presses sail, shall come abreast of the second ship, the second ship adapts her sail to keep in this bearing; and so on in succession, each observing to keep the ship that immediately preceded her in the evolution in a line with herself, perpendicular to the direction of the wind; and the whole fleet will now be running before the wind (see fig. 28.) But if it is intended that the fleet shall steer any other given course than that before the wind, the whole fleet may then alter together to the proposed course.

To change to the third order of sailing from the line of battle: The whole fleet bears away together ten points; the headmost half of the fleet, including the centre ship, carry an equal degree of sail, in order to preserve their line of bearing; each ship of the remainder of the fleet carries less sail in succession, such as will form and preserve on the other line of bearing with respect to that upon which they were ranged before the evolution; and by this means the fleet will be formed in the third order of sailing. See fig. 29.

To change from the line of battle to the fifth order of sailing on the same tack: In the treatise of *Naval Tactics*, published in the second volume of *The Elements of Rigging and Seamanship*, there are various rules for performing this evolution, according as the different squadrons in the line of

battle are intended to form the weather, the centre, and the lee columns, in the order of sailing. We shall give two of them as examples.

1. When it is intended to change from the line of battle to this order of sailing, so as that the van shall form the weather, and the rear the lee column, and the fleet at the same time keep as much to windward as possible; the van and centre tack together, and run close-hauled in bow and quarter-line; the rear moves on in its former course under an easy sail. When each ship of the centre is abreast of its correspondent ship in the rear, the centre retacks; the van stands on until the centre and rear come up, and then retacks, and all the columns regulate their distances. See fig. 30.

2. When it is intended that the van shall form the lee, and the rear the weather column; the van bears away together under an easy sail, and goes at right angles with the line ahead: the centre at the same time goes away two points free, and each ship steers for that ship of the van respectively which is to be abreast of her when in column. The leader of the van must determine the distance, by not hauling up with his division until his ship and the sternmost ship of the centre-column, which is drawn up with him, are in a line at right angles with the wind: They then both stand on under an easy sail, while the rear crowding sail passes to the windward of both. See fig. 31.

To change from the line of battle to the fifth order of sailing on the other tack: This evolution may be performed in as many ways as the former, according to the intended positions of the different columns; but in such a Work as our's, it may be sufficient to observe, that,

1. When the van is meant to form the weather, and the rear the lee column: The van tacks in succession; the leader of the centre tacks when the leader of the van is passing him exactly to windward, and his division follows him; the rear manœuvres in the same manner with respect to the centre. See fig. 32.

2. When the rear is to form the weather, and the van the lee column: The van tacks in succession; and when about, either brings to, or shortens sail, to allow the other columns time to form. The centre and rear then carry sail, and tack in succession. The centre tacks when its leader has the centre of the lee-column in a line at right angles with the wind, or when its centre passes astern of the lee-column. When the centre is about, it regulates its rate of sailing by the lee-column, either by bringing to or making equal sail; and thus both wait for the rear to pass to windward. The rear tacks when its leader has the first ship of the lee column in a line at right angles with the wind, or when its centre ship passes astern of the last ship of the centre-column. See fig. 33.

To change from the line of battle to the order of retreat: The leader bears away four points; and all the fleet following close hauled, they will come to file off in succession at the same point in the van ship's wake, till the centre ship arrives at the angle where the evolution began. Then the order of retreat will be formed, and any course whatever may be steered, since the two wings will be equal and in order on the starboard and larboard lines of bearing, forming consequently between them an angle of 135 degrees. Fig. 34. represents the order of retreat formed from the line of battle, the whole fleet going four points free.

CHAP. V. To Manœuvre the Line of Battle.

THE method of forming the line of battle, when the ships are in no previous order, has already been explained. In this place it is intended to point out some of the various evolutions

Manœuvre the Line of Battle. 55
 evolutions that are, or may be, performed by a fleet which is already formed in line of battle.

To form the line on the other tack by tacking in succession. 55
 The fleet being in line of battle, to form the line on the other tack, by tacking in succession: The headmost ship of the fleet tacks first, having previously made more sail, or the second having shortened sail, in order to increase the interval between them; for it often happens that one or two cables length are run over before the ship ahead has been able to fill her sails on the other tack. When the first ship is about, either the second makes more sail, or the third shortens sail; and then the second tacks as soon as she has gained the wake of the leader, the helm being put down at the instant she opens the weather quarter of the first ship, which is already on the other tack. In like manner the third, fourth, &c. ships tack each at the instant it has gained the wake of the leader; and those ships already about must preserve their assigned distances, by shortening sail, if necessary, until the whole fleet is on the other tack. If a ship misses stays, she is immediately to fill again on the same tack, and make sail with all possible expedition, taking care to keep as close as possible to the wind, and not to fall off to leeward. By this means she will get ahead and to windward of those which follow her; and they will perform successively their evolutions in the wake of the ships which are already on the other tack, only standing on a little farther than they would have done if the ship ahead had not missed stays. The ship that missed stays will return sooner to her station, by making all possible sail to windward of the line. See fig. 35.

Without tacking in succession. 56
 To form the line on the other tack without tacking in succession: The whole fleet veers together: the rear ship hauls her wind on the other tack, and stands on, while all the others go two points free on the other tack, and haul up as they successively gain the wake of the leading ship. Thus the rear of the line on the one tack becomes the van on the other tack. See fig. 36.

To veer in succession. 57
 The line to veer in succession: The van ship of the line veers round, and steers four points free on the other tack; and when she is clear of the rear ship of the line, she hauls her wind; the rest follow, and haul up in succession. See fig. 37.

To tack and retack. 58
 The line to tack and retack together: In tacking together, the sternmost ship of the line puts in stays; then her second ahead puts her helm down; and so on through the whole line, to prevent the ship ahead from falling on board the ships astern. The fleet will then be in bow and quarter line; from which, if tacking together, no ship must put in stays till the ship on her weather quarter is in the act of tacking.

To bear away together. 59
 The line bear away together, preserving their bearing for the line: The rear begins this evolution, the sternmost ship bearing away the number of points proposed; and so on as quickly as possible, to prevent falling on board of each other.

To turn to windward. 60
 To turn to windward in line of battle: When the fleet has sea-room, the most advantageous method of gaining to windward is, that all the ships of the fleet may go about together; as by this means the whole fleet will gain as much to windward as in the case of a single ship. The fleet will be in line of battle on the one board, and in bow and quarter line on the other. This is also the most proper method to get to windward on a coast when the wind is parallel to the land: But if the fleet is turning to windward in a strait or between two shores, the fleet should tack in succession; for if all the ships tacked together, the van would be soon in with the land on one side, and soon after the fleet had retacked the rear would be in with the land on the other side: hence this would occasion a number of short boards. In

passing through a strait, other circumstances are also to be attended to, as tides, &c.

To interchange the van and centre squadrons: The van bears away a little, and brings to; the centre passes on to windward, edging a little, to get ahead of the former van on the same line; the rear, coming on under an easy sail, edges away likewise, to obtain the wake of the new centre squadron. See fig. 38.

To interchange the van and rear squadrons: The van and centre squadrons bear away a little, and then bring to, the van observing to bear away a little more to the leeward than the centre. The rear stands on to gain the head of the line; and when abreast of the former van, the centre fills, and both standing on, form ahead of the new rear, by edging down until they are in a line with it. See fig. 39.

To interchange the centre and rear squadrons: The van stands on under an easy sail, while the centre bears away a little and brings to, and the rear at the same time carries a press of sail to pass the centre to windward and get into the wake of the van. The van and centre then edge away to gain the line with the new rear squadron, which then fills. See fig. 40.

The van to pass and form the rear: The van squadron edges away a little and brings to; the other two squadrons, crowding sail, stand on till they get ahead of the new rear, and then edge away a little to form in the line; after which the rear fills.

The rear to pass and form the van: The van and centre bear away a little and bring to; the rear makes sail, passes ahead of both, and then edges away to form on the same line. These two manœuvres are so simple as not to stand in need of illustration by figures.

CHAP. VI. *To Manœuvre a Fleet formed in the Fifth Order of Sailing.*

THIS order of sailing is very advantageous for a numerous fleet, as it keeps the ships closer together, and therefore more connected with each other than either of the three first orders. The method of forming this order is shown in Chap. II.: and the method of manœuvring in it, which with very little alteration is also applicable to the fourth order, is to be the subject of this chapter.

To tack the columns in succession: The ships of the lee-column having more distance to run before they can recover their position, must go about first in succession. When the centre leader finds himself abreast of the leader to leeward of him, or at right angles with the close-hauled line on the other tack, upon which the lee leader is now moving, he tacks, and is followed in succession by his division. The weather-column paying the same regard to the centre-column, manœuvres in the same manner (see fig. 41.) In this evolution the weather-column still continues to windward; and should the columns have closed too much, or be too far asunder, either of which may happen from the inequality in the rate of sailing of the different ships, the order may be recovered either by the lee or windward column bearing away, so as to make an angle equal to that proposed, as two points, between any column, and a line joining the leader of that column and the sternmost ship of the next column.

If this evolution is to be performed in the night, the weather-column must tack first. In order to prevent the risk of one column passing through the van of the other columns, the next column must not tack till its leader is sensible that many ships of the column immediately to windward are about. When about, the leaders make little sail, while their followers make successively a little more, in order to form their respective columns. The columns which are com-

Manœuvre a Fleet in the Fifth Order of Sailing.

61
 To interchange the van and

centre squadrons. 62
 Van and rear squadrons.

63
 The van Centre and rear squadrons.

64
 The van to pass to the rear.

65
 The rear to pass to the van.

66
 To manœuvre the fifth order of sailing.

67
 To tack in succession.

Manœuvre
a Fleet in
the Fifth
Order of
Sailing.

pletely about should either bring to and wait for the next, or should just keep steerage way; thus the former weather-column should wait for the centre, and both should then wait for the former lee-column. In this evolution the weather and lee columns will be interchanged. As some risk may attend the execution of this at night, it is most advisable to tack the columns together, and sail in bow and quarter line; because, should it become necessary to retack, or should the wind change before the completion of this evolution, much confusion might ensue. By tacking together this will be avoided.

68
To tack to-
gether.

To tack the columns together: The sternmost ships of the three columns put in stays together; and when they are observed to be so, their seconds ahead immediately put their helm down, and so on through the whole fleet. Each column will then be in bow and quarter line. See fig. 42.

69
To veer in
succession.

To veer the columns in succession: The leader of the lee-column veers round, and steers four points free upon the other tack, followed by the ships of that division; and of which, when he is clear of the sternmost ships, he hauls up. The centre and weather columns perform successively the same evolution, observing to continue standing on till they successively bring the point at which the lee-column began to veer to bear in a right line to leeward of them. They likewise successively spring their luffs when the point at which the lee-column hauled its wind bears right to leeward (fig. 43.) Each column having the same distance to run, if the evolution be well executed, the leaders of the windward columns will find themselves, when they spring their luffs, exactly abreast of the leader of the lee-column, and so will all the other ships. But the making or shortening sail will at all events rectify the inequality of sailing.

70
To turn to
windward.

To turn to windward in the fifth order of sailing: Let the ships of the fleet be so arranged, that the leaders, and also the corresponding ships of the columns, may be in the direction of the wind; as by this means the fleet will gain more to windward, and at the same time be less liable to disorder. Now the van ships of the columns tack at the same instant, and are followed in succession each by the remaining ships of the division, when they reach the wake of their leaders, or the same point when they went about; hence there will always be three ships in stays at the same time until the whole fleet has got on the other tack. The fleet then stands on any assigned distance, and then retacks in the same manner as before. See fig. 44.

Plate
cccxvii.

71
To inter-
change the
weather
and centre
columns.

To interchange the weather and centre columns: The weather and lee columns lie to, or only keep steerage way. The centre column tacks together; and forming a bow and quarter line, goes close-hauled to gain the wake of the weather-column; it then retacks together, and stands on, while the weather-column bears away to its new station in the centre, and the lee-column fills. See fig. 45.

72
The wea-
ther and
lee co-
lums.

To interchange the weather and lee columns: The centre column brings to; the lee column stands on under a press of sail; and when its sternmost ship can pass to windward of the van of the centre column, which will be when the centre ship of the lee column is in a line perpendicular to the direction of the wind with the van of the centre column, the lee column then tacks together, and stands on close-hauled till it comes in a line with the centre column, when it goes large two points to get into the station which the weather-column left; and then veers together, hauling the wind for the other tack. At the beginning of the evolution, the weather column bears away together under little sail, and goes large six points on the other tack, so as to get into the wake of the centre column; it then hauls to the former tack, going two points large, till it ranges abreast of the

centre column, when it brings to, and waits for the new weather column. See fig. 46.

To interchange the centre and lee columns: The centre and weather columns bring to, or keep steerage way, as is most convenient; the lee column tacks together, and presses sail to gain the wake of the centre column; which, when they have effected, they retack together and stand on; the centre-column then edges away under an easy sail, steering, if it lay to, eight points from the wind, and if it kept steerage way only two points, until it comes into the station of the lee column, where it hauls to the wind; while the weather-column fills and stands on; and the order is re-established by shortening or making sail, according to circumstances.

The weather column to pass to leeward: The weather-column stands on under very little sail, while the centre and lee-columns tack together, and carry a press of sail till they reach the wake of the weather-column, when they retack, and crowd sail till they come up with the weather-column; and when they have gained the wake of the weather-column, it bears away two points, to gain its station to leeward, and then hauls to the wind or brings to till the new weather and centre columns come up. See fig. 47.

The lee-column to pass to windward: The weather and centre columns bring to, while the lee column carries sail and tacks in succession as soon as the leading ship can weather the headmost ship of the weather-column; and when arrived upon the line on which the weather-column is formed, it re-tacks in succession, forms on the same line, and either brings to or stands on under very little sail. If it brings to, the other two columns bear away together two points, to put themselves abreast of the column now to windward; but if the new weather-column stood on under an easy sail, they may bear away only one point to gain their proper stations. See fig. 48.

As it is of the utmost importance that each ship be in her respective station, both to preserve order, and that the various evolutions may be more readily performed, the officer of the watch will therefore be ever anxious to preserve the station of his ship. This he may do by his quadrant; but the more ready method for this purpose is by means of the NAVAL SQUARE, which is constructed as follows:

Upon some convenient place at the middle of the quarter-deck, describe the square ABCD (fig. 49.), of which the sides AD and BC are parallel to the keel; through the centre line G draw the line EF parallel to AD or BC, and draw the diagonals AC and BD; bisect the angles EGD, EGC by the straight lines GH, GI, and the naval square will be constructed. Now since the angles FGD, FGC are equal to four points, being each half a right angle; therefore the angles EGD, EGC are each equal to 12 points, and consequently the angles EGH, EGI are each equal to six points. Hence, if a ship is running close-hauled on the starboard tack, in the direction FE, the direction of the wind will be IG, and her close-hauled course on the other tack will be GC: But if she be running in the same direction FE upon the larboard tack, her close-hauled course on the starboard tack will be in the direction GD.

In order now to apply the naval square to the keeping of ships in their respective stations, let the fleet be formed in the fifth order of sailing close-hauled, the corresponding ships of the columns coinciding with the direction of the wind, in order to turn to windward with greater facility. The corresponding ships in the column must be kept in the direction of GH, or GI, according to the direction of the wind and the tack they are upon, while all the ships of

To restore the same column must be in the direction of EF. See the Order of Battle fig. 50.

Upon Shifts of the Wind. Again, let the fleet be in three columns in one of the lines of bearing, the ship being close-hauled on the other tack. The ships of each column will be in the direction of one of the diagonals, while the corresponding ships of the other columns will be in the direction of the other diagonal (fig. 51). It will also be the same if the columns are in one line of bearing, and going four points large on the same tack. The application of the naval square in other cases will be obvious.

CHAP. VII. To restore or reform the Order of Battle upon Shifts of the Wind.

79 To restore the order of battle upon shifts of the wind on the same tack, the wind coming forward less than six points.

1. Let it be intended to restore the order of battle on the same tack, the wind coming forward, and shifting ahead less than six points. In this case, the whole fleet is to bring to except the leader; who, in order that the same distances between the ships may be preserved when the line is reformed, steers a course *ab* (fig. 52.), such as to be at right angles to the middle point between the former and present direction of the wind: hence the course he must steer will be known by adding half the number of points the wind has shifted to eight points, and applying this sum to the former close-hauled course. As soon as the leader has arrived at the new close-hauled line with respect to the second ship ahead, that ship immediately fills, and bears away the same number of points as the leader; and when both these have reached the close-hauled line with respect to the third ship, she also fills, and bears away. In like manner the remaining part of the fleet bear away in succession; and when they have got into the close-hauled line *bc* with the sternmost ship, they all haul their wind at the same instant, and the sternmost ship fills and stands on close-hauled.

A very expeditious method of performing this evolution is as follows: The whole fleet having fallen off as soon as the wind shifted the same number of points which it changed, the leader bears away eight points from the middle point between the former and present directions of the wind; or, if the wind has shifted near six points, in this case the leader must bear away eight points from the new direction of the wind; but then the fleet will be closer than before, and the leader hauls his wind as soon as the sternmost ship bears on the close-hauled line from him: The second ship bears away when she has reached the wake of the leader, and also hauls her wind when she has again gained his wake. In like manner the third, fourth, &c. ships bear away, and also haul their wind in succession, until the sternmost and the whole line is formed again. See fig. 53.

80 Four points. If the wind shifts exactly four points ahead, the whole fleet is to veer round till the heads of all the ships are directed to the point exactly opposite to their former course; and the rear ship, which has now become the van, is to run four points large upon her new tack, and the rest of the fleet to follow her in succession; and when the last ship, which was the former leader, is got into the wake of the headmost in the line, the whole fleet is to veer together, and the order will be reformed on the former tack.

If the wind shifts eight points forward, the ships are to

81 Eight points.

veer round altogether till their heads are on the point of the compass opposite to their former course; then the rear ship, having become the van, is to haul close by the wind on the same board; all the other ships are to haul up in succession, and range in the wake of the leading ship; and when the last ship is in her station, the order will be reformed on the same tack.

82 If the wind changes 12 points exactly, the fleet must veer round together, and haul their wind in succession on the first tack. Twelve points.

83 2. The wind coming forward, and the order of battle to be reformed on the other tack. To reform the order of battle on the other tack, the wind coming forward less than six points.

If the wind shifts ahead less than six points, all the ships of the fleet are to veer round, till their heads come to the opposite point of the compass with respect to their former course; and then the rear ship, which is now become the van, is to haul close by the wind on that tack, and the other ships follow her in succession. From hence the fleet might pass to the line of battle on the former tack by veering in succession. If the wind comes ahead more than six points, but less than twelve, the fleet is to manœuvre in the same manner as before. If the wind comes ahead exactly twelve points, the tack is to be changed. 84 Between six and twelve points. 85 Twelve points.

86 3. When the wind shifts aft, and the order of battle to be reformed on the same tack. The wind coming aft and the order of battle to be reformed on the same tack.

If the wind has shifted less than two points, the leader hauls his wind, the fleet stands on as before, and each ship hauls her wind in succession as she gains the wake of the leader. If it is intended to change the tack, the whole fleet tack together, and the sternmost ship, which now becomes the leader, hauls up, and the rest bear down and haul up in succession. 87 On the other tack.

If the wind changes sixteen points, all the ships brace about for the other tack immediately, by which means the fleet will be going four points large; then the ships tack, ing or veering instantly together, the order of battle will be restored or formed again on the same tack as they were before the wind changed. 88 The wind changing sixteen points.

CHAP. VIII. Of the Battle.

89 In a naval engagement, the present mode, as has already been observed, is to draw up the fleet in a straight line upon one of the close-hauled lines under an easy sail. The frigates, fire-ships, transports, &c. are placed at proper distances on the other side, with respect to the enemy (B). The distance between two adjacent ships in the line is usually about a cable's length; but the admiral increases or diminishes this interval according to circumstances. The nearer, however, the ships are to each other, the stronger is the line, and the more difficult to be broken or forced by the enemy; but still there must be a sufficient interval left, so that if a ship receive considerable damage, she may be got out of the line without becoming foul or falling aboard of the ship next astern, which would be the means of putting the whole line in confusion. 90 Its advantages by being close.

The strength of a fleet depends also more on the largeness of the ships, and the weight of the metal, than in their number. The fewer the number of ships in a fleet, the more distinctly will the signals be perceived and answered by those near the extremities of the line; the better also will the order be. 91 And composed of large ships though fewer in number.

(B) Several able officers have been of opinion, that when fleets are ranged in order of battle, instead of being close-hauled, they should have the wind two points free, or upon the beam. Some of the reasons alleged in support of this opinion are, that the ships can more easily keep their stations; and if any ship should happen to fall to leeward, she may easily regain her station, which would be almost impossible were the fleet close-hauled.

The Battle. der of battle be kept, and the fleet more easily manœuvred. A large ship is not so soon disabled as a small one; and in the case of a three-decker, although the upper deck should happen to be confused with the wreck of broken masts, yards, &c. and hence it being scarcely possible to work the guns on that deck, yet if the weather be not tempestuous, the guns on the other two decks may be worked. If boarding should be deemed practicable, it is evident that the large ship, upon account of the height of her side, as well as for other reasons, will have greatly the advantage over one of a less size. Large ships are also for the most part more able to encounter a storm than small ones; and in a gale of wind large ships have commonly the advantage in point of sailing. Hence it is obvious, that a fleet composed of large ships may have greatly the advantage over a fleet consisting of less ships, though much more numerous.

As in a naval engagement the two fleets are drawn up close-hauled, on two lines parallel to each other, one of these fleets is therefore to the windward of the other. The windward fleet has several advantages not possessed by the fleet to leeward, and the leeward fleet has also advantages over the weather fleet. The advantages and disadvantages of each of these fleets are as follow:

92
Advantages of the fleet to windward.

The fleet to windward may approach the leeward fleet at pleasure, and can therefore determine the time of commencement of the action. If the weather fleet is more numerous, it may send down a detachment of ships on the rear of the leeward fleet, and thereby put it into confusion. If any of the ships of the fleet to leeward should be disabled, the fleet to windward may with great ease send down their fire-ships upon them, or send a detachment after any part that gives way. The weather fleet may board if the admiral thinks proper; and it is scarcely incommoded with the smoke, which is carried off by the wind to the fleet to leeward.

93
Disadvantages of the fleet to windward.

The disadvantages of the fleet to windward are, an inability to quit the fight when once engaged, without being obliged to pass through the enemy's line, which is extremely dangerous; because the ships being already very much injured before they are obliged to fly, they must expect to be still more so; and as they have it no longer in their power to form the order of retreat, this manœuvre is absolutely a desperate one. If the fleet to windward tack altogether, in order to get off, the line to leeward may do the same, after having raked the weather ships in stays, and follow them on the other tack, with the advantage of having gained the wind of the centre and rear divisions of the flying line. If it blow fresh, it is seldom that weather ships have their lower deck guns sufficiently elevated; whence it results, that the ship being a little inclined on the lee side, the guns often run out again at their ports after being fired, which very much retards the service of the artillery, since the guns are obliged to be bowled in again every time for loading; and oftentimes they can make no use at all of their lower tier. Again, such of the ships as are so disabled as to be obliged to quit the line, cannot easily do it, because in veering, for want of being able to tack, they fall between the two lines, where they are raked ahead, and by that means completely put in disorder: but should they be fortunate enough to be able to finish their evolution, it is still very difficult for them, disabled as they are, to get to windward of their line, and very often they fall foul of the next ships astern of them, which have it scarcely in their power to prevent the accident on account of the fire and smoke, especially if the line is much contracted; and should these perceive it, and try to avoid being run foul of by falling back on their next ship astern, and so on thus successively, it might happen, that from one to the other a great part of the fleet being obliged to manœuvre, their fire would

lessen, and very often cease, by their covering each other; when, if the enemy take the advantage of this critical moment, the disorder increases, and all is lost. But these inconveniences may be partly prevented by having the disabled ships quickly towed out of the line by the boats of the fleet, which for that purpose should always be hoisted out from each ship before the engagement begins. Otherwise, if the ships in the weather line, not being too close, have the necessary space to observe what passes ahead of them, and to manœuvre, they ought to range themselves to leeward of the disabled ship, in order to cover her, and approach nearer to the enemy; all the other ships bearing up also together to preserve the line.

The ships in the line to leeward have the advantage of serving with facility and effect their lower deck guns in all weathers proper for fleets to come to action: they can quit the engagement at pleasure: their disabled ships can without difficulty quit their stations when necessity requires it: they can form the order of retreat with more readiness, or continue the action as long as convenient: in short, the lee line of battle, if superior in number, can also double the enemy, by making some of the ships in the van or rear to tack, and put one of the extremities of the enemy's line between two fires; and if they are formed in time, they may cannonade the enemy while bearing down to the attack.

The disadvantages of the fleet to leeward are, its being very much annoyed by the smoke, and a continued shower of fire from the wads falling on board, repelled by the wind, which if not attended to may be productive of dreadful consequences. The ships of the line to leeward cannot attempt to board those of the other whatever may be their inclination for it; they can hardly do more than accept the battle, without being able to determine either time or distance: it is even with great difficulty that they can avoid being boarded, or prevent their line from being broken, if the weather ships are bent upon doing it; and their fire-ships are very seldom of use.

A general rule for the adoption of either the weather or lee gage cannot be laid down. Sometimes the one is preferable, and sometimes the other; and very often the commander in chief has it not in his power to make an option.

Having proceeded so far with respect to the line of battle, it may not be improper to introduce in this place an account of a naval engagement, with the conduct to be observed previous to, and during the time of, its continuance.

The engagement will not begin till the admiral makes the signal, unless an action is insensibly brought on by some unavoidable circumstances in the line, or position of the van or rear of both fleets in forming or approaching each other. The admiral in such case will make the proper signal for the van or rear, by the distinguishing flag of either of these divisions, which will undoubtedly regulate the necessary manœuvres of the rest of the fleet throughout the whole line.

During the time of an engagement the greatest silence is to be observed in each ship; no one must quit his post upon pain of death; and should any one happen to refuse obeying an officer, he shall be put to death on the spot; the same also shall be done to any one who shall hide himself, or feign to be wounded. The wounded must be carried or conducted to the surgeon by those who have been appointed by the captain for that purpose. Should any one discover an advantage to be taken, he shall inform the officer who stands nearest him. No kind of rigging whatever is to be touched without an order. Should any dangerous shot be received at the water line of the ship, such of the calkers, or carpenters, or any other person who perceives it, shall inform in private the captain with it, without saying a word of the same to any one else upon pain of death, unless

The Battle. unless it be a superior officer; the same precaution shall also be observed about any part of the ship catching fire.

99 The fleet to carry little sail. Whilst the fleets are engaged, the admiral carries but little sail; in this, however, he must conduct himself by the motions of the enemy, the ships always observing to keep close in the line; and if any ship happen to get out of the line, the ship which immediately follows is to pay no regard to her, but endeavour to keep her station in the line.

100 No captain to quit his post in the line. A captain must not quit his post in the line upon any pretence whatever, unless his ship should be so greatly damaged as to render her incapable of continuing the action. The little sail a fleet is under at such a time may in general give the ships, though damaged in their rigging, &c. time enough to repair their defects, without causing an unnecessary interruption in the line, by withdrawing out of action when their service might perhaps be of the utmost importance to the rest of the fleet.

101 Nor make an attack without order from the admiral. A captain, through too impetuous a desire of distinguishing himself, ought never to break the order of the line, however inviting the advantage of an attack might then appear to him to secure success: he must wait with patience the signal of the admiral or commanding officer of his division, because it is always more essential to preserve and support a close line in action, as it constitutes the principal strength of a fleet in general, than to attend to a particular attack between two ships, which commonly decides but little with regard to the whole, however glorious in appearance, unless with a view at the same time of taking or destroying a flag ship of the enemy's, and where success alone, even then, can justify the attempt.

102 The admiral to be supported by his seconds. The two immediate seconds to the admiral ought to direct part of their fire against the enemy's flag-ship, or any other that may attack their admiral; so that their chief attention should be employed more in his defence than in that of their own proper ship, as they must sacrifice every other consideration to the honour of their flag.

The same attention must likewise be paid to any other ship that may find herself engaged with one of the enemy's flag-ships; the next to her ahead and astern should serve in that respect as seconds, by dividing part of their fire against such flag-officer, in order to make him strike the sooner.

If any flag-officer stand in need of being assisted, he will of course make a signal for the corps de reserve; or if there should be none, he will signify the same to his division; on which his two seconds, with those nearest him, will close in to cover him, and continue the action. The frigates of his squadron will likewise be ready to give him the necessary assistance; and if he should still continue the attack, he will in a particular manner be supported by his whole division.

103 And the ships mutually to protect each other. Those ships which happen to be most exposed to danger will naturally make the ordinary signals upon the occasion if they should receive any hurt or damage, in order to be supported by such of the line as are nearest to them.

104 The body of reserve. When a fleet is so far superior in number as to be able to extend itself both ahead and astern considerably beyond the enemy's line, the admiral generally forms the excess into a body of reserve, drawn up in a line on the other side of the fleet with respect to the enemy. If the body of reserve is to windward, the ships composing it are to be drawn up in a line with the frigates nearest abreast of the centre; but if to leeward, a little ahead of them; being careful at the same time to keep within reach of observing distinctly all the signals and motions of the fleet, and to be ready to replace such of the ships as may happen to be dismasted or driven out of the line, where all intervals must be properly

strengthened, and carefully filled up again without loss of time. The body of reserve is usually formed at the same time with the line, to prevent any irregularity that may happen on leaving any intervals or openings; yet the admiral may draw ships out of the line to form a body of reserve, according to the time and circumstances of his situation.

106 The oldest captain except the commander to relieve the first disabled ship. The oldest captain, after the senior officer who commands the body of reserve, ought to relieve the first, or close that part of the line which the disabled ship has been obliged to quit; and so on successively of the rest.

The commanding officer of the body of reserve will not be detached with the whole corps, unless on some pressing occasion, to fortify the line, where such reinforcement is absolutely necessary. If to defend one of the flag-officers of the three squadrons, he will be followed by the next senior officer of the reserve who was not before detached, in order to place themselves as seconds, the first ahead and the other astern of the flag they are to support, without any diminution of the honour of his own proper seconds at the same time, as they are only called in through necessity on that emergency, being not engaged before, and consequently better able to assist and support the admiral; their duty being likewise to exert their utmost efforts in attacking, or, if possible, in boarding, the enemy's flag-ship, to force him to yield, except they are particularly ordered off to some other quarter or part of the line.

108 The admiral may order the whole body of reserve to reinforce one of the three squadrons of the fleet, as he may see occasion; which, when he does, the body must make all the sail it can, that each ship may place herself successively, the first in the first interval, the second in the second interval, and so on throughout. If a part only of the body of reserve is wanted, the proper signal will be made accordingly.

109 The body of reserve to rejoin the line. When the admiral has no further occasion for the body of reserve, he will make the proper signal for the ships composing it to resume their respective posts in the line, and these ships will repeat the signals.

110 In case a captain should think boarding practicable. If any captain in the fleet think he can board with success one of the enemy's ships, he will signify the same to the admiral by hoisting the boarding flag, together with his particular pendant, to be more plainly distinguished: the admiral in return will make the proper signal of approbation, or otherwise if he disapprove of the attempt, by letting fly that ship's particular pendant that she may observe the signal the better. Before the captain make the signal, he ought to consider well the ill consequences that might attend such an enterprise if he should fail of success; for the breaking of the order or disposition of the line, by quitting his post, may be of much greater disadvantage to the whole, than any advantage arising from his victory, except that over a flag-ship.

111 The fire-ships to prepare when the signal is made to engage. When the admiral makes the signal for his fleet to prepare for action, the fire-ships will at the same time get ready to their grappling-irons, fire-engines, &c. for boarding, and will likewise dispose all their combustibles into their proper channels of communication, &c. as soon as possible after the action begins: all which, when ready, they will take care to make known by signal to the particular division or squadron they belong to, and they of course will repeat the same to the admirals.

112 To be out of the reach of the enemy's guns. The fire-ships must be particularly careful in placing themselves out of the reach of the enemy's guns, which they may do abreast and under shelter of their own ships in the line, and not in the openings between the ships, unless to prevent any of the enemy's ships that should attempt to force through their line, when they must in such cases use their utmost efforts to prevent them. They ought always

The Battle to be very attentive to the admiral's signals, as well as those of the commanding officer of the particular squadron they belong to, that they may lose no time when the signal is made for them to act, which they must quickly answer by a signal in return.

113 The fire-ship in her way to the enemy to be assisted by the ship ahead of which she passes. Although no ship in the line should be particularly appointed to lead down or protect the fire-ships, besides the frigates already ordered for that particular purpose; yet the ship ahead of which the fire-ship passes in her way to the enemy, whatever division she may belong to, is to escort her, and must assist her with a boat well manned and armed, as well as any other succour she may stand in need of: The two next ships to her must likewise give her all necessary assistance. The captain of a fire-ship is to consider, in short, that he is answerable for the event, in proportion as he expects to be honourably rewarded if he succeed in so daring and hazardous an enterprise.

114 Particular description of a naval engagement between two ships. Since a general engagement of fleets or squadrons of men of war is nothing else than a variety of particular actions of single ships with each other, in a line of battle, it may not be improper to begin by describing the latter, and then proceed to represent the usual manner of conducting the former.

115 Divided into preparation, action, and repair. The whole economy of a naval engagement may be arranged under the following heads; namely, the *preparation*, the *action*, and the *repair* or *refitting* for the purposes of navigation.

116 The preparation. The *preparation* is begun by issuing the orders to clear the ship for action, which is repeated by the boatswain and his mates at all the hatchways or staircases leading to the different batteries. As the management of the artillery, in a vessel of war, requires a considerable number of men, it is evident that the officers and sailors must be restrained to a narrow space in their usual habitations, in order to preserve the internal regularity of the ship. Hence the hammocs, or hanging-beds, of the latter are crowded together as close as possible between the decks, each of them being limited to the breadth of 14 inches. They are hung parallel to each other, in rows stretching from one side of the ship to the other, nearly throughout her whole length, so as to admit of no passage but by stooping under them. As the cannon therefore cannot be worked while the hammocs are suspended in this situation, it becomes necessary to remove them as quickly as possible. By this circumstance a double advantage is obtained: the batteries of cannon are immediately cleared of an encumbrance, and the hammocs are converted into a sort of parapet, to prevent the execution of small-shot on the quarter-deck, tops, and fore-castle. At the summons of the boatswain, *Up all hammocs!* every sailor repairs to his own, and, having stowed his bedding properly, he cords it up firmly with a lashing or line provided for that purpose. He then carries it to the quarter-deck, poop, or fore-castle, or wherever it may be necessary. As each side of the quarter-deck and poop is furnished with a double net-work, supported by iron cranes fixed immediately above the gunnel or top of the ship's side, the hammocs thus corded are firmly stowed by the quarter-master between the two parts of the netting, so as to form an excellent barrier. The tops, waiste, and fore-castle, are then fenced in the same manner.

Whilst these offices are performed below, the boatswain and his mates are employed in securing the sail-yards, to prevent them from tumbling down when the ship is cannonaded, as she might thereby be disabled and rendered incapable of attack, retreat, or pursuit. The yards are now likewise secured by strong chains or ropes, additional to those by which they are usually suspended. The boatswain also provides the necessary materials to repair the rigging, wherever it may be damaged by the shot of the enemy, and to

supply whatever parts of it may be entirely destroyed. The carpenter and his mates, in the meanwhile, prepare shot-plugs and mauls, to close up any dangerous breaches that may be made near the surface of the water; and provide the iron-work necessary to refit the chain-pumps, in case their machinery should be wounded in the engagement. The gunner with his mates and quarter-gunners is busied in examining the cannon of the different batteries, to see that their charges are thoroughly dry and fit for execution; to have every thing ready for furnishing the great guns and small arms with powder as soon as the action begins; and to keep a sufficient number of cartridges continually filled, to supply the place of those expended in battle. The master and his mates are attentive to have the sails properly trimmed, according to the situation of the ship; and to reduce or multiply them, as occasion requires, with all possible expedition. The lieutenants visit the different decks, to see that they are effectually cleared of all encumbrance, so that nothing may retard the execution of the artillery; and to enjoin the other officers to diligence and alertness, in making the necessary dispositions for the expected engagement, so that every thing may be in readiness at a moment's warning.

When the hostile ships have approached each other to a competent nearness, the drums beat to arms: The boatswain and his mates pipe, *All hands to quarters!* at every hatchway: All the persons appointed to manage the great guns immediately repair to their respective stations: The crows, handspikes, rammers, sponges, powder-horns, matches, and train tackles, are placed in order by the side of every cannon: The hatches are immediately laid, to prevent any one from deserting his post by escaping into the lower apartments: The marines are drawn up in rank and file on the quarter-deck, poop, and fore-castle: The lashings of the great guns are cast loose, and the tompons withdrawn: The whole artillery, above and below, is run out at the ports, and levelled to the point blank range, ready for firing.

117 The necessary preparations being completed, and the officers and crew ready at their respective stations to obey the order, the commencement of the action is determined by the mutual distance and situation of the adverse ships, or by the signal from the commander in chief of the fleet or squadron. The cannon being levelled in parallel rows projecting from the ship's side, the most natural order of battle is evidently to range the ships abreast of each other, especially if the engagement is general. The most convenient distance is properly within the point-blank range of a musket, so that all the artillery may do effectual execution.

The combat usually begins by a vigorous cannonade, accompanied with the whole efforts of the swivel-guns and the small arms. The method of firing in platoons, or volleys of cannon at once, appears inconvenient in the sea-service, and perhaps should never be attempted unless in the battering of a fortification. The sides and decks of the ship, although sufficiently strong for all the purposes of war, would be too much shaken by so violent an explosion and recoil. The general rule observed on this occasion throughout the ship, is to load, fire, and sponge the guns with all possible expedition, yet without confusion or precipitation. The captain of each gun is particularly enjoined to fire only when the piece is properly directed to its object, that the shot may not be fruitlessly expended. The lieutenants, who command the different batteries, traverse the deck to see that the battle is prosecuted with vivacity; and to exhort the men to their duty. The midshipmen second these injunctions, and give the necessary assistance, wherever it may be required, at the guns committed to their charge. The gunner

The Battle The gunner should be particularly attentive that all the artillery is sufficiently supplied with powder, and that the cartridges are carefully conveyed along the decks in covered boxes. The havoc produced by a continuation of this mutual assault may be readily conjectured by the reader's imagination: battering, penetrating, and splintering the sides and decks; shattering or dismounting the cannon; mangling and destroying the rigging; cutting asunder or carrying away the masts and yards; piercing and tearing the sails so as to render them useless; and wounding, disabling, or killing the ship's company! The comparative vigour and resolution of the assailants to effect these pernicious consequences in each other, generally determine their success or defeat: we say generally, because the fate of the combat may sometimes be decided by an unforeseen incident, equally fortunate for the one and fatal to the other. The defeated ship having acknowledged the victory by striking her colours, is immediately taken possession of by the conqueror, who secures her officers and crew as prisoners in his own ship; and invests his principal officer with the command of the prize until a captain is appointed by the commander in chief.

118
Repair.

The engagement being concluded, they begin to repair: the cannon are secured by their breechings and tackles with all convenient expedition. Whatever sails have been rendered unserviceable are unbent; and the wounded masts and yards struck upon deck, and fished or replaced by others. The standing rigging is knotted, and the running-rigging spliced wherever necessary. Proper sails are bent in the room of those which have been displaced as useless. The carpenter and his mates are employed in repairing the breaches made in the ship's hull, by shot-plugs, pieces of plank, and sheet-lead. The gunner and his assistants are busied in replenishing the allotted number of charged cartridges, to supply the place of those which have been expended, and in refitting whatever furniture of the cannon may have been damaged by the action.

Such is the usual process and consequence of an engagement between two ships of war, which may be considered as an epitome of a general battle between fleets or squadrons. The latter, however, involves a greater variety of incidents, and necessarily requires more comprehensive skill and judgment in the commanding officer. A short account of which also we shall next proceed to lay before our readers.

119
Description
of an en-
gagement
between
two fleets.

When the admiral or commander in chief of a naval armament has discovered an enemy's fleet, his principal concern is usually to approach it, and endeavour to come to action as soon as possible. Every inferior consideration must be sacrificed to this important object, and every rule of action should tend to hasten and prepare for so material an event. The state of the wind, and the situation of his adversary, will in some measure dictate the conduct necessary to be pursued with regard to the disposition of his ships on this occasion. To facilitate the execution of the admiral's orders, the whole fleet is ranged into three squadrons, each of which is classed into three divisions, under the command of different officers. Before the action begins, the adverse fleets are drawn up in two lines, as formerly described. As soon as the admiral displays the signal for the line of battle, the several divisions separate from the columns, in which they were disposed in the usual order of sailing, and every ship crowds sail to get into its station in the wake of the next ahead; and a proper distance from each other is regularly observed from the van to the rear. The admiral, however, will occasionally contract or extend his line, so as to conform to the length of that of his adversary, whose neglect or inferior skill on this occasion he will naturally convert to his own advantage, as well as to prevent his own

line from being doubled; a circumstance which might throw his van and rear into confusion.

When the adverse fleets approach each other, the courses are commonly hauled up in the brails, and the topgallant-sails and stay-sails furled. The movement of each ship is chiefly regulated by the main and foretop sails and the jib; the mizen topsail being reserved to hasten or retard the course of the ship; and, in fine, by filling or backing, hoisting or lowering it, to determine her velocity.

The signal for a general engagement is usually displayed when the opposite fleets are sufficiently within the range of point blank shot, so that they may level the artillery with certainty of execution, which is near enough for a line of battle. The action is begun and carried on throughout the fleet in the manner we have already described between single ships. The various exigencies of the combat call forth the skill and resources of the admiral to keep his line as complete as possible when it has been unequally attacked; by ordering ships from those in reserve to supply the place of others which have suffered greatly by the action; by directing his fire-ships at a convenient time to fall aboard the enemy; by detaching ships from one part of the line or wing which is stronger to another which is greatly pressed by superior force, and requires assistance. His vigilance is ever necessary to review the situation of the enemy from van to rear; every motion of whom he should, if possible, anticipate and frustrate. He should seize the favourable moments of occasion, which are rapid in their progress, and never return. Far from being disconcerted by any unforeseen incident, he should endeavour, if possible, to make it subservient to his design. His experience and reflection will naturally furnish him with every method of intelligence to discover the state of his different squadrons and divisions. Signals of inquiry and answers, of request and assent, of command and obedience, will be displayed and repeated on this occasion. Tenders and boats will also continually be detached between the admiral and the commanders of the several squadrons or divisions.

As the danger presses on him, he ought to be fortified by resolution and presence of mind; because the whole fleet is committed to his charge, and the conduct of his officers may in a great degree be influenced by his intrepidity and perseverance. In short, his renown or infamy may depend on the fate of the day.

CHAP. IX. *Manœuvres performed by adverse Fleets when in sight of each other.*

To dispute the weather-gage with the enemy.—When the enemy is to windward, and it is wished to gain the weather-gage of him, the fleet to leeward should avoid extending itself the length of the enemy's line, in order to oblige them to edge down upon theirs, if they intend to attack them; which will be a mean, if they still persist in doing so, of losing the advantage of the wind.

It is impossible for a fleet to leeward to gain to windward so long as the enemy keep their wind, unless a change happens in their favour: therefore all that a fleet to leeward can do, must be to wait with patience for such a change; which they will undoubtedly avail themselves of, as well as any mistake or inadvertency the enemy may commit in the mean time. And as long as the fleet to leeward does not extend its line the length of the enemy's, it will be impossible for the latter to bring them to action without running the hazard, by bearing down, of losing the advantage of the wind, which both fleets will be so desirous of preserving.

120
To dispute
the wind
with the
enemy.

Manœuvres performed by adverse fleets when in sight of each other.

Hence, that an admiral may benefit by the shifts of the wind that frequently happen, he must in a manner force them; which will not appear so extraordinary to officers of any experience, who know what winds reign most on the coast, or off the head-lands, where they may expect an enemy; and though an admiral may be sometimes out in his conjecture, he also as often succeeds so happily as to gain the advantage of his enemy. The disposition of projecting head-lands, and the setting of tides or currents, also contribute greatly towards gaining the wind of the enemy.

Again, the fleet to windward ought to keep that to leeward as much as possible always abreast of it; because, by doing so, they will preserve the advantage they have, unless the wind changes much against them. They should force them likewise to keep their wind, unless they think it more prudent not to engage; but when that is the case, they should keep entirely out of fight.

The following observations, with respect to the shifting of the wind, are given by M. Bourdé de Villehuet: 1. If the weather fleet be in order of battle, and the wind draw ahead, the lee fleet, if they be ahead and in order of battle, ought to box off on the same tack as before, in order to tack in succession in the wake of one another, to restore the order of battle; drawing at the same time a great deal to windward. This manœuvre may even be the means of weathering the enemy, if the wind should shift much; for they have no other method to regain the order of battle, without losing much ground: though they will always lose a great deal with respect to the position of the enemy to leeward.

2. If the lee fleet be astern, and the wind shifts ast while they are on the contrary tack with the enemy in order of sailing on one line, the lee fleet ought to tack or veer altogether, and at the same instant; because this shift of wind will be ahead for all the ships in respect to their tacks then on board, and astern in respect to the order of battle. When the van ship is full on the other tack, as well as all the rest in their former order of battle, she shall haul by the wind, while the rest of the fleet run large on their first line of battle as many points as the wind has shifted ast, to get into her wake successively, and restore the order of battle while approaching the enemy; by which they gain the wind of him, or else double him if the shift has been great; for the only means they have of restoring the line of battle is by the van ship hauling by the wind, and the rest coming into her wake in succession. If the shift of the wind was four points, the fleet to leeward would be obliged still to perform the same manœuvre, that they might go about, after a certain time, successively to windward of the enemy, who could only in the mean time have tacked all together, to bring their fleet suddenly in a line of battle on the other board.

If, when the wind shifts ast, the lee fleet is astern in order of battle, and the enemy be on the other tack in the order of sailing, the leading ship must haul close to the wind immediately, while the other vessels will, in succession, bear away as many points as the wind has shifted, in order to perform the same manœuvre and restore the line of battle. By observing this mode of manœuvring, you will approach the enemy, and gain as much to windward of him as possible, or get even the weather-gage of him entirely, if the wind has shifted considerably. The rear ship of the fleet to leeward may immediately keep close to this new wind on the same board, while all the rest of the fleet, after having tacked together and at the same time, will come and place themselves close by the wind in her wake, where they are again to tack successively, in order to follow their rear ship, which is now become the leader, and which may break the ene-

my's line, or at least gain the wind of him. But, to be able to go through this evolution, you must have nothing to fear from the enemy; for the fleet will be obliged to go about twice before the order of battle can be restored. The weather fleet ought to keep their wind as close as possible, holding the enemy always exactly to leeward of them, by keeping on the same tack as he; and if the wind shifts a little, and becomes favourable to the enemy which is to leeward, the weather ships are then to keep exactly their wind, without caring for the preservation of the line, unless the two fleets be very near one another.

To force the enemy to action.

1. When the enemy has the weather-gage.—When two adverse fleets are in sight of each other, an engagement is almost unavoidable: For since it may be presumed that the fastest sailing ships of the one fleet will sail faster than the slowest sailing vessels of the other fleet, hence the fleet that is in pursuit will gain upon the other. The lee fleet, which is wishing to bring on an engagement, must therefore keep always on the same tack with the weather fleet; and taking care to keep them so exactly abreast as to prevent the least danger of losing sight of them, and hence be ready to take the advantage of the first favourable shift of wind to make the attack. Night is certainly the time when an alteration of the course may be best attempted. But the lee fleet is to have frigates on the look-out; which, by signals, will continually give notice of the manœuvre and course of the retreating fleet to windward; which, by these means, is always exposed to be pursued without being able to get off unseen, and must sooner or later be compelled to come to action, unless they can get into some port, or a gale of wind should come to rescue them by dispersing both fleets, and thus furnish the means of retreating in a storm.

2. When the enemy is to leeward.—If the lee fleet keep close to the wind in the order of battle, the fleet to windward is to stand on in the same manner till it is abreast of the enemy, ship to ship, when they are all together, and at the same time, to bear away, and steer exactly so as to bring their respective opponents, in the adverse line, on the same point of the compass with them; observing the principles of chasing, which are to be observed by every chaser to windward. Thus the fleets will be near enough to begin the action, in presenting the bow of each ship to her opponent in the order of sailing, which will be easily changed for the line of battle, by all the ships hauling close to the wind together, in the moment which precedes the beginning of the action.

If the fleet to leeward be inclined to engage, it might bring to, to prevent losing time; as, by this manœuvre, less time will be requisite for the weather fleet to join them: then they will fill as soon as the action begins, because it is more favourable to a lee line to be advancing ahead; since, if a ship be disabled in the weather line (which is obliged to follow with the topsails full), she will infallibly drop, and run foul of the next vessel astern of her, covered with fire and smoke, which may be productive of great disorder.

As the lee fleet fills and stands on close by the wind, it is necessary that the weather-line should be abreast and parallel to the other before they bear away to come within the requisite distance for action, in order that the van ship of the weather fleet should always keep to windward of the leading ship of the lee line, and be guarded against such a shift of wind as might come ahead: which would not be the case if they were astern of the van ship in the lee fleet; which, as well as the rest of the line, would be able then to double them to windward, by tacking in succession.

Another reason for the weather line being right abreast of the enemy to leeward, and for every ship steering on the same point in approaching her opponent in the leeward line

Manœuvres performed by adverse Fleets when in sight of each other.

of battle, is, that the fleets may be placed exactly parallel to each other; for, as the weather line must not be astern, because of the risk of the wind coming more forward, neither must they be ahead of the line to leeward, in case the wind should come aft; for then the lee fleet, keeping close by the wind in the wake of their leading ship, might, by this shift, be as far to windward as the opposing fleet, or even get the weather-gage of them. But if the weather fleet keep exactly abreast of the other, they will always be in a situation to preserve their advantage without exposing themselves. It is, notwithstanding, that those ships keeping more away than the line to leeward will find themselves, when come within gun-shot, in a very disagreeable situation with respect to the enemy's ships, which will have it then in their power to rake them as they bear down. This may occasion much disorder among the ships of the weather line, which, for that moment, have it not in their power to fire their whole broadside at the enemy, who has the advantage of beginning the action.

If the lee fleet bear away four points to move their order of battle on the other tack and avoid the action, sailing off in succession in the wake of the van ship, the weather line, by bearing away all together eight points, cannot fail, as both fleets are supposed to sail equally, to pass through the middle of their line, and force them to fight with disadvantage, if their extent be double the distance between the two fleets. If the extent of the fleet be less than the above limitation, then the weather fleet will divide the lee fleet more unequally; and if the distance between the fleets be considerable, the weather fleet will not be able to break through the line.

If the lee fleet bear away four points all together, being of equal extent with the fleet to windward, and their distance from each other equal to half the length of one of the lines; should the weather fleet bear away at the same time eight points, they will approach very near the sternmost of the retreating fleet; but they will not have it in their power to cut off any part of that fleet, even with an equality of sailing; so that the only advantage gained by this manœuvre will be an ability of attacking the rear, and bringing it to action.

If the van ship and the rest of the weather fleet had a sufficient velocity to keep the centre ship of the lee line on the same point of bearing; in that case the leading ship may break through the enemy's line about the middle ship of the centre division: for, supposing the fleets in order of battle, on the starboard tack, steering east, with the wind at south-south-east, being at two leagues distance from each other, both the lines being four leagues in extent; then the lee line bearing away all together four points, will run north-east, while the fleet to windward, bearing away all together eight points, will steer north; the van ship of which will keep the centre division of the lee line on the point of bearing north-west. As she is supposed to be able to continue in this position, it follows, that the van of the weather line must close the centre of the flying line to leeward, after having run four leagues. The time and distance necessary to cut off a retreating fleet may always be known according to the last supposition. Should the lee fleet get upon the other tack and run large, still preserving the order of battle, they will be still sooner closed and forced to action by the weather fleet, who have only to keep away from eight to nine points on the same tack, or run right before the wind.

The weather fleet can always force the lee one to action, whatever movements they make; for, if they run with the wind right aft in order of battle, they cannot, supposing an equality of sailing, avoid being closed or broken nearly about the centre by the weather line, which has only to steer two

points on each tack nearer the wind than the retreating fleet. So that the rear of the weather fleet having bore away no more than eight points, will be found at the end of a certain time to have approached extremely near the centre of the retreating fleet; and, in a short time more, will be able to bring their rear to action. The weather fleet have yet another advantage; because, as their ships have the wind on the quarter, they sail with greater celerity than those of the lee fleet, which run before the wind. The lee fleet being absolutely determined to fly, has therefore no other expedient left to prolong time but to combat in the order of retreat right before the wind, or on the same course as the pursuing fleet; for other advantages are not to be relied on, if pursued by a victorious foe.

If, from all that has been said, it results that it is not possible for a fleet of equal force to avoid an action, how then must it be with one much inferior? The more numerous has nothing to do but to form a detachment of superior sailers, which will gain upon the lee fleet and begin the action, while some others approach to finish it. Whence we may conclude, that when in presence of too powerful an enemy, it will never be possible to avoid an action if he is determined to come to one.

To avoid coming to Action.

1. When the enemy is to windward.—The lee fleet, which is wishing as much as possible to avoid an engagement, ought to form the order of retreat to fly from the enemy if they are in view of him, and run on the same tack as their chaser. But if he is yet out of sight, and they have intelligence of his approach by their frigates which are looking out, they may run large from the hostile fleet, without confining themselves to keep the wind exactly aft, unless they be in the order of retreat. There are, however, circumstances when the lee fleet may run with the wind aft, without assuming the order of retreat; as, for example, when they wish to gain time, or resolved to engage the enemy, if they still continue to pursue them. But except on such extraordinary occasions, a fleet should not fly before the enemy without being in the order of retreat, as the rear is then in the best situation to extricate themselves in case of accident.

2. When the enemy is to leeward.—The weather fleet can scarcely ever be forced to engage; because it can always continue on that tack which increases its distance from the enemy, by standing on one tack, while the enemy continues upon the other. If the wind was to remain on the same point of the compass for any considerable space of time, it would be very easy for the fleet to windward to keep in sight of the enemy, without being under any apprehensions of being forced to come to action; but the inconstancy of the wind obliges the most experienced admiral to avoid meeting the enemy when he thinks it improper to engage him.

To double the Enemy, or to bring a Part of his Fleet between two Fires.

1. When the enemy has the weather-gage.—The fleet which attempts to double an enemy ought always to be superior to him in number of ships. The lee fleet ought to endeavour to range exactly abreast of, and parallel to, the weather fleet, so that the van or rear may extend beyond their line, in order to over-reach them, by tacking in succession to double to windward their van or rear, and bring them between two fires. Provided this manœuvre be properly executed, it will be impossible for the ships in the weather line, thus pressed, to continue long in their ports; for there is no vessel closely attacked by two others of equal force which can long resist being overcome, since it is always in the power of one of them to get into such a position

Manœuvres performed by adverse Fleets when in sight of each other.

123 To avoid an action, the enemy being to windward.

124 The enemy being to leeward.

125 To double the enemy when he has the weather-gage.

Elements of Rigging and Seamanship, vol. ii. p. 386.

Manœuvres performed by adverse fleets when in sight of each other.

tion as to be able, without much danger on her side, to destroy the enemy in a very short time. But whether the most advantageous evolution is to double the van or the rear, is necessary to be considered; for there is so considerable an advantage attending each of these evolutions, that either of them may in a very little time determine the fate of the battle.

As, in the present case, the enemy is supposed to be to windward, either their van or rear may be doubled; but the van may with the greatest facility, because, if they are engaged by the ships abreast of them, those which are advanced ahead will be able, by making all sail, to get on the perpendicular to the direction of the wind with the van of the enemy, and tack in succession to gain the wind of them on the other board, thus keeping them to leeward; and when they are come sufficiently to windward, they are again to go about, in order to keep the two headmost ships of the enemy's line continually under their fire. If there be two or three ships to tack in succession and gain the wind of the enemy, they may edge down on the van of the weather line at pleasure, keeping themselves a little to windward of it; and as that van is already engaged by the other ships abreast on the other side, she must necessarily be soon disabled. If they bear away, they must drop upon the line with which they are engaged to leeward, while the ships to windward still continue to cannonade them. If they attempt going about, in order to attack more closely the ships to windward, they will be raked, while in stays, by their opponents to leeward and to windward, who enfilading them with whole broadsides, which they cannot return, must absolutely complete their disorder. If they make sail, in order to frustrate the design of the ships inclined to double, those with which they are engaged abreast to leeward have only to perform the same manœuvre, and keep them under their fire; while the others, after having harassed them as much as possible, will do their best to perform the same manœuvre on the succeeding ships.

The captains destined to double the enemy ought to be men of known ability, as well as of approved courage. They should not be ordered upon that service but in weather fit for sailing at the rate of three knots an hour at least; and, for the greater promptitude and certainty of success, none but the best going ships are to be employed.

If any of the ships in the van of the weather line happen to be disabled in their masts or yards, as will most probably be the case after having been between two fires, they will drop astern and run foul of the next which follows, and these again of their subsequent comrades; at last, disorder will become prevalent, by ships running foul of each other, or manœuvring to avoid the same accident: so that the order of battle will be broken; while, on the other hand, the line to leeward is preserved with all the advantage possible. The ships which have gained the wind of the enemy will, by continuing their manœuvre, augment the confusion; engaging, however, no more than they like; and if, by chance or misfortune, they should be crippled, it will not certainly be an easy matter for them to extricate themselves. But as they may, on the other tack, drop astern to windward of the enemy's line, or veer again like him, they must extricate themselves as well as they can, and always advantageously enough if, by doubling the van, they are able to throw it into disorder.

If the rear of the lee fleet be extended beyond the sternmost ship of the weather line, they will be obliged, if they want to double the rear of the enemy to windward, to make sail and tack in succession; in which manœuvre the headmost ship of those destined for this service is to go about first; then, continuing to keep up a brisk cannonade as they come to the wind, they will go and heave about again a little to windward of the rear of the enemy, in order to bring their

stern ships between two fires: and should they have the good fortune to oblige them to bear away, they must go on successively from one ship to another, as long as they find they succeed in forcing them to give way. Should disorder take place in the rear of the weather fleet, it will not be near so prejudicial to the enemy as if it had happened in the van; on the contrary, it may turn out to be of some advantage to them. But the vessels combating to windward can easily withdraw from the fight, by backing astern when they find themselves too hard pressed.

2. When an enemy is to leeward.—The ships of the weather-line having extended their van beyond that of the lee-line, are to veer, in order to bring the headmost ships of the enemy's line between two fires. But, let them do as they will, there never can result so much advantage from this manœuvre as when doubling a fleet to windward, because the disabled ships can always veer with facility. True it is, they cannot fail becoming at the same time the prey of the enemy; for both those which have doubled them, and those with which they are engaged abreast in the weather-line, will always have it in their power jointly to press as close as they think proper.

If the ships which have doubled the van of the lee fleet, with which they are engaged, be disabled, they will be obliged, as they cannot make sail, to pass along the lee-line; and they cannot escape being totally destroyed if they do not bear away before the wind, to get out of gun-shot; during which manœuvre they cannot avoid being still in a very disagreeable situation.

Should the sternmost ships of the weather fleet be disabled in doubling the enemy's rear, they have only, if they want to extricate themselves, to drop astern, and let the two fleets advance ahead; and after having refitted themselves, they will reassume their posts.

To avoid being doubled.

1. The enemy being to windward.—For this purpose, it has been proposed to extend the line, by leaving a greater interval between the ships towards the centre than in the van or rear; but in this case the line runs the risk of being divided, unless prevented by a corps de reserve, consisting of a few ships of the line and fire-ships. It has also been proposed as a general rule, that the flag-officers of the lee fleet should oppose themselves to those of the enemy; by which means several of the enemy's ships will be rendered useless in the intervals. This method has, however, its inconveniences; as sometimes the van and rear of each division may be exposed to the fire of two ships at the same time: nor is the last division out of danger of being doubled. In order to remedy these defects, the larger ships ought to be placed in the van and rear of each division; and the whole fleet must regulate its sailing in such a manner that the rear of the enemy may not be astern of the rear of the last division.

Other methods have been proposed to avoid being doubled; as, that each squadron of the lee fleet should attack its corresponding squadron in the weather fleet; each division of the lee fleet, however, extending its line far enough to prevent the enemy from leaving any ships astern of it, but rather ahead. It has also been proposed, that the lee fleet should extend its line as long as the enemy's line. This method will be advantageous for the lee fleet, provided it is composed of ships of superior force, though fewer in number, than the enemy. In other cases, it is probably the worst method that can be followed by the lee fleet, as it gives the enemy's fleet all the advantage it can desire of exerting its whole force upon the inferior line.

2. When the enemy is to leeward.—The weather fleet is to keep astern of the enemy, so that the van of the weather fleet may be opposed to and attack the enemy's centre: hence

Manœuvres performed by adverse fleets when in sight of each other.

126 To double the enemy when he is to leeward.

Ibid. P. 388.

127 To avoid being doubled, the enemy being to windward.

128

The enemy being to leeward.

Manœuvres performed by adverse fleets when in sight of each other.

hence the enemy's van will become useless for some time; and if it should attempt to tack and double upon the weather fleet, much time will be lost in performing that evolution; and it also runs the risk of being separated by the calm which generally happens in the course of a sea-engagement in consequence of the continual discharge of cannon. A considerable interval might also be left between the centre and van, provided the necessary precautions be taken to prevent the van from being cut off.

To force the enemy's line.

119
To force the enemy's line.

This is a manœuvre which the lee fleet may execute to gain the advantage of the wind. It is performed by the van ship, if within gun-shot, tacking when she and the centre ship of the weather line are on a perpendicular to the direction of the wind; then all the lee fleet tack in succession, and thus may pass through the enemy's line, or perhaps a little more towards the enemy's van, and go about again in succession to windward of him. But as he will not be long, without doubt, before he performs the same manœuvre, he will thus be able to regain the wind, if he be not forced to give way before his evolution is finished. The enemy to windward may even cause his van ship to tack, as well as the rest of the van squadron to follow in succession, as soon as the leading ship of the lee fleet shall have passed through his line and be ready to go about; by which means he will bring them between two fires. This manœuvre, well executed, might perhaps give no little trouble to the ship attempting to force the line.

This evolution may be performed with advantage, if, by some accident or fault in the manœuvring, the centre division of the weather-line be separated from their van or rear. For example, when the centre division to windward is encumbered with disabled ships, then the ships of the centre division of the fleet to leeward, having all sails set, are to tack in succession, and force with promptitude through the weather fleet, leaving their own van division to engage that of the enemy on the other tack.

To prevent the line being forced.

130
To prevent the line being forced.

When the ships of the fleet go about in succession, in order to force the weather line, the whole line to windward is to tack together, and at the same time to get upon the same board as the lee fleet; then that fleet will neither be able to traverse nor join them. To perform this evolution with advantage, it will be requisite to permit some of the van ships of the lee fleet to pass to windward; then the weather fleet must go all about rapidly, in order to put and keep them between two fires: thus may these ships be destroyed without their own fleet being able to give them any effectual assistance.

It is easy to perceive, from what has been said, that there is little occasion to fear being traversed, as such a manœuvre may turn out to be more prejudicial than advantageous to those who perform it. Nevertheless, it may and ought to be put in practice when the weather fleet leave such vacancies between their divisions as to allow some ships of the lee fleet to be inactive. In this case, the ships which are without opponents abreast of them are made to tack, with all sails set, in succession, and pass through these intervals in the weather line, in order to double the centre division, or any other part of it, and bring it between two fires.

CHAP. X. *Of Chasing.*

131
Chasing in the case of single ships.

1. In the case of single ships.—It is scarcely necessary to observe, that the ship which gives chase is usually called the *chaser*, and that which is pursued is called the *chase*. Unless the chaser be the fastest sailing vessel of the two, it is generally supposed that she will seldom or never come up

with the chase: but we have heard experienced officers say, that a chasing ship, sailing equally fast, in other circumstances, will gain on her chase; because she has an object to steer by, whereas the chase cannot steer so nicely by the compass. In what follows, however, we shall suppose the chaser to be the fastest sailer.

Of Chasing.

When the chase is to windward, it is evident that as soon as she perceives a strange ship which she takes for an enemy, she will haul her wind, in order to prolong the chase, as otherwise her retreat would be soon cut off. The chaser then stands on also nearly close-hauled until he has the chase on his beam; he then tacks, and stands on close-hauled until the chase is again on his beam, and then retacks. In this manner he continues tacking every time he brings the chase perpendicular to his course on either board; and by manœuvring in this manner, it is very certain that the chaser will, by the superiority only of his sailing, join the other in the shortest time. For since the chaser tacks always as soon as the chase is perpendicular to his course, she is then at the shortest distance possible on that board; and since the chaser is supposed to be the fastest sailer, these shortest distances will decrease every time the chaser tacks. It is therefore of advantage to the chase to keep constantly on the same course, without losing her time in going about; as tacking cannot be so favourable to her as to her adversary, whose sailing is superior. If the chaser should so little understand his profession as to stand on a long way, and tack in the wake of the chase, the best thing she can do is to heave in stays, and pass to windward of him on the other tack, unless she would have a superiority in going large; for if the chaser persists in tacking in the wake of the other ship, it is an unquestionable fact that the chase will be very much prolonged.

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The chase being to windward.

The chase being to leeward, the chaser is to steer that course by which he thinks he will gain most upon her. If, after having run a short time, the chase is found to draw more ast, the chaser is then to bear away a little more; but if the chase draws ahead, the pursuer is to haul up a little, and by this means the course may be so regulated that the chase may always bear on the same point of the compass, and then the chaser will get up with the chase in the shortest time possible; for were any other course steered than that which keeps the chase always on the same point, the chaser would then be either too far ahead, or too far astern; and hence the chase would be prolonged.

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The chase being to leeward.

The chase ought to run upon that course which will carry her directly from the chaser; and, in general, to consult which is her best trim with respect to the wind, that she may move with the greatest rapidity possible from the ship which pursues her; for some vessels have more advantage in going large than others, some with the wind right ast, and others again are to be found that sail best close-hauled; so that attention should be paid by the officer to the known qualities of his ship, in order to take the most advantageous direction capable to effect a retreat.

Another method has also been proposed for chasing a ship to leeward, that is, by constantly steering directly for the chase: In this case, the tract the pursuer describes through the water is called the line or *curve of pursuit*. In order to illustrate this, let A (fig. 54.) represent the pursuer, and B the chase directly to leeward of it, and running with less velocity than the pursuer, in the direction BC, perpendicular to that of the wind. Now, to construct this curve, let Bb be the distance run by the chase in any short interval of time; join Ab, and make A1 equal to the distance run by the pursuer in the same time. Again, make bc, cd, de, ef, &c. each equal to Bb; join 1c, and make 12 equal to A1; join 2d, and make 23 equal to A1; in like manner proceed.

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Curve of pursuit.

Of Chasing.

ceed until the two distances carried forward meet as at C, and a curve described through the points A, 1, 2, 3, &c. will represent nearly the curve of pursuit; and the less the interval AI is taken, the more accurate will the curve be formed. In this particular case the length of the distance BC may be found as follows, provided the distance AB and the proportional velocities of the two ships be known.

Let the velocity of the chase be expressed by a fraction, that of the chaser being unity. Multiply the given distance AB by this fraction, and divide the product by the complement of the square of the same fraction, and the quotient will be the distance run by the chase E. Let AB, the distance of the chase directly to the leeward of the pursuer, be 12 miles, and the velocity of the chase three-fourths of that of the chaser; the distance to be run by the chase before she is overtaken is required?

Now $\frac{12 \times \frac{3}{4}}{1 - \frac{3}{4}} = \frac{9}{\frac{1}{4}} = 9 \times 4 = 36$ miles; and since the velocity of the pursuer to that of the chase is as 4 to 3: hence the distance run by the chaser will be $= 36 \times \frac{3}{4} = 27$ miles.

As the pursuer alters his course at every point, and since it is presumed his ship will sail better with the wind in one direction, with respect to her course, than in another, her velocity will therefore be different at different points of the course. Thus suppose her to sail faster when the wind is upon the quarter, her velocity will constantly increase until she has attained a certain point, and then it will decrease: hence in real practice this curve will not be precisely the same as above, and of course the measure of BC will differ a little from the preceding determination. The investigation of the foregoing rule is in Simpson's Fluxions, p. 516.; and the application of the curve of pursuit in Sir George Pococke's engagement in the East Indies in the year 1758, is given in Clerk's Essay on Naval Tactics, p. 160. It must be confessed, however, that Mr Simpson's investigation, though a pretty specimen of mathematical investigation, proceeds on certain physical assumptions, which are by no means sanctioned by experience. See what has been said of these assumptions and principles in the articles *RESISTANCE of Fluids*, and *SEAMANSHIP*.

Hitherto we have considered chasing in the case of single

ships only; the same rules are also applicable to fleets: we shall, however, subjoin the following remarks with respect to chasing as practised by fleets.

If the whole fleet is to give chase, the admiral will make the proper signal; and then each ship will instantly make all the sail possible. If the retreating fleet is not much inferior to the other, a few of the fastest sailing vessels only are to be detached from the victorious fleet, in order to pick up any stragglers or those ships which may have fallen astern; and the remaining part of the fleet will keep in the same line or order of sailing as the retreating fleet, so that they may, if possible, force them to action. But if the retreating fleet is much inferior, the admiral of the superior fleet will make the signal for a general chase; and then each ship will immediately crowd all the sail possible after the retreating fleet; or, if the chase be still less numerous, the admiral will detach one of the squadrons of his fleet, by hoisting the proper signal for that purpose, and he will follow with the remainder of the fleet. The squadron that chases, or the cruizers detached from the fleet, should be very careful not to engage too far in the chase for fear of being overpowered; but at the same time to endeavour to satisfy themselves as much as may be in their power with regard to the object of their chase. They must pay great attention to the admiral's signals at all times; and in order to prevent separation, they should collect themselves before night, especially if there be any appearance of thick or foggy weather coming on, and endeavour to join the fleet again. The ships are diligently to observe when the admiral makes the signal to give over chase; that each regarding the admiral's ship as a fixed point, is to work back or make sail into her station, to form the order or line again as expeditiously as the nature of the chase and the distance will permit.

When a fleet is obliged to run from an enemy who is in sight, it is usual to draw up the ships in that form or order, called the *order of retreat*, which has been already described; and the admiral, when hard pursued, without any probability of escaping, ought, if practicable, to run his ships ashore, rather than suffer them to be taken afloat, and thereby transfer additional strength to the enemy. In short, nothing should be neglected that may contribute to the preservation of his fleet, or prevent any part of it from falling into the hands of the conqueror.

PART II. NEW SYSTEM OF NAVAL TACTICS.

WE have now laid before our readers as comprehensive a view as the limits prescribed to such articles will permit of the various evolutions usually practised by fleets in naval war. Though we have transcribed liberally from the most approved writers on the subject, we doubt not but the scientific officer will perceive that we have compiled awkwardly and unskilfully: but we are not seamen ourselves; and the generosity of BRITISH officers will pardon the blunders into which mere literary landmen could hardly avoid falling. The young seaman, who has the noble ambition to excel in his profession, will consult the authors whom we have mentioned in our introduction, in whose works he will find our deficiencies amply supplied; but that the present article may be as complete as we can make it, a view must be given of the system of tactics proposed by the Viscount de Grenier and our countryman Mr Clerk; because, whether these systems shall ever be adopted or not, they are the offspring of ingenuity, and as such merit attention.

CHAP. I. View of De Grenier's Tactics.

OF all the orders, that of battle is the most important in naval tactics; but the order of battle which was first formed in the last century by the Duke of York, and has been continued in use to the present day, the Viscount de Grenier thinks extremely defective. Various causes may conspire to render the task of breaking it not difficult. Its great extent must make it no easy matter for the admiral to judge what orders are proper to be issued to the ships stationed in its extremities; whilst his signals, however distinctly made, are liable to be mistaken by the commanders of those ships. The extremities of a long line are necessarily defenceless, especially if it be to leeward; because, after it is formed, the enemy may throw himself with a superior number on its van or rear, and put that squadron to flight before assistance can be sent to it from the other squadrons. These defects the Viscount de Grenier thinks may be remedied by never

View of
De Greni-
er's Tactics.138
Remedied
by the Vis-
count de
Grenier.

never presenting to the enemy any part of a fleet without its being flanked; so that were the commander of the adverse fleet to attack those parts which hitherto have been reckoned weakest, he might find himself defeated when he looked for conquest. With this view he proposes a new order of battle; in which the fleet, composed of three divisions, instead of being drawn up in one line as usual, shall be ranged on the three sides of a regular lozenge, formed by the intersecting of the two close-hauled lines. It is obvious that one of the divisions of a fleet ranged in this manner will always be formed in the order of battle; whilst the two others, resting upon the first ship ahead and the last astern of that division, will be formed on the close-hauled line opposite, and will stand on chequerwise on the same tack with the ships which are in the line of battle, serving to cover the headmost and sternmost of those ships, and thereby prevent the enemy from penetrating the line or doubling the rear.

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Object of
De Greni-
er's Tactics.

Our author thinks it a great mistake, though very generally fallen into, that the weather-gage is of any advantage to a fleet equal in force to its enemy and willing to engage. To him the great art of war at sea appears to consist in drawing or keeping to *windward a part of the adverse fleet*, and collecting all one's forces against that part; and it is chiefly to effect this purpose that he proposes his new system of tactics. The reader, who would understand his principles, must never lose sight of this evident truth, that each ship of a fleet necessarily occupies at all times the centre of an horizon; which the author divides into two unequal parts, calling the greater the *direct and graduated space*, and the less the *indirect, crossed, and ungraduated space*. The reason of these appellations is, that on the greater segment of the horizontal circle there are twenty different points, which may be marked by degrees from one of the close-hauled lines to the other, and to which a ship may sail from the centre by so many direct courses without tacking; whereas to the other twelve points, including that from which the wind blows, she cannot arrive but by steering cross courses, which must necessarily delay her progress.

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Principles
of his sy-
stem.

Suppose now a fleet to leeward, so disposed as that only a part of it can fight with another equally numerous, and ranged to windward in a single line; and let the lee fleet be ranged on the three sides of a lozenge *ab, cd, ef* (fig. 55.). The squadron *ab*, which is most to windward, being drawn up in line of battle, cannot be fought but by an equal number *AB* of the weather fleet *AB, CD, F*. All the rest of that fleet therefore must remain inactive, unless the ships which are not engaged should try to pass to leeward of the fleet *ab, cd, ef*. But should the ships of the weather fleet, which are placed between *B* and *F*, bear away as they appear in the figure between *Ci* and *Fi*, it is evident that the ships between *A* and *B*, which are fighting to windward, cannot bear away with them. Suppose now that, after the ships between *Ci* and *Fi* have passed to leeward, the squadrons *cd, ef*, which are ranged according to the new system, and have not yet been engaged, should come to windward and join with their friends *ab* against that squadron of the enemy *AB* which is still to windward and engaged; it seems almost inevitable but that the squadron *AB* must be destroyed by so great a superiority, before it could receive any assistance from the ships to leeward between *Ci* and *Fi*. No doubt those ships would endeavour to succour their friends; but with respect to them, the squadron *AB* must be considered as placed in that part of the horizon which our author calls *crossed and indirect*, and to which they would not be able to repair but by steering alternately the two close-hauled lines; and assistance brought by so tedious a course would come too late to be of essential service. It is from this apparently well supported conclusion that the viscount de Grenier

deduces the propriety of his proposed orders of sailing and order of battle.

Of orders of sailing, he thinks, there can be no occasion for more than three; one, when a fleet is to pass a strait; another, when it steers in an open sea, either looking for the enemy or trying to avoid him; and the third, when it has an extensive cruise to perform, in which the ships should be so disposed as not to be surprised or cut off by the enemy. His first order of sailing differs not from that in common use. It is and must be observed (says he) in any narrow road, whatever may be the occasion of its narrowness, whether rocks or sands.

In the second order of sailing, when the fleet is looking for the enemy or trying to avoid him, the columns *ab, cd, ef*, are to be formed on three sides of a regular lozenge, and ranged on the two close-hauled lines. The ships of the two divisions *cd, ef*, sometimes to windward (as in fig. 56.), and sometimes to leeward (as in fig. 57.), of the third division *ab*, are to be formed on two parallels of one of the close-hauled lines in the wakes of their respective headmost ships; and the third division *ab* is to be ranged ahead or astern of the two others on the other close-hauled line, and nevertheless to steer chequerwise the same course as the two divisions *cd* and *ef*. When *ab* is to windward of *cd* and *ef* (fig. 57.), the viscount calls that the *primitive* windward order of sailing; and when to leeward (fig. 56.), the fleet is in the *leeward primitive* order of sailing. The position of the three divisions in the windward primitive order of sailing is the same for the order of battle natural; for the order of retreat; and for the order of circumvallation, when the object is to separate from the hostile fleet a part of its ships in order to engage the remainder with more advantage. The position of the three divisions in the leeward primitive order of sailing is also the same for the order of battle inverted; for the order of chasing; and for the order of convoy; so that in no possible case, when looking for the enemy or wishing to avoid him, need the admiral perplex himself with more than these two positions on the one or the other tack, whatever movements he may wish the fleet to make.

In the third order of sailing, the divisions *cd* and *ef*, instead of bearing on the headmost and sternmost ships of the division *ab*, may be very conveniently placed at considerable distances from that division, without the smallest danger of being surprised by the enemy, provided the ships of each of the divisions keep always their respective positions in the two lines of bearing. For if we suppose the three divisions to be in such positions that *ab* and *ef* are at the distance of six leagues from each other (fig. 58), and that the two divisions *cd* and *ef* rest on the extremities of the base of the triangle *STV*, while the centre ship of the division *ab* rests on its summit *T*; none of the divisions could be cut off by an enemy, however formidable, seen from its centre ship at the distance of six leagues. For if, upon the proper signal being thrown out, the division *ab* should steer from *T* towards *X*, on the course opposite to the close-hauled line it steered before, and the two divisions *cd* and *ef* steer from *V* and *S* towards *X* likewise; it is plain that each of these three divisions would have only three leagues to run in order to join the other two in the windward primitive order of sailing, which is the same with the order of battle natural; whilst the enemy, which was first perceived at the distance of six leagues, must necessarily run nine before he could come up with the nearest of these squadrons. And if frigates were placed ahead, and in the intervals between the divisions, at the points *y y y* to windward and leeward of the fleet, the enemy might be seen at a still greater distance, and the danger of surprise be still so much less.

View of
De Greni-
er's Tactics.141
First order
of sailing.142
Second or-
der.Plate
CCCCXCVIII.143
Third or-
der.

View of
De Greni-
er's Tactics.
144
Order of
battle.

We have said, that the position of the three divisions in the primitive orders of sailing is the same with our author's proposed order of battle; but there is this difference between them, that in the order of battle only the ships of one of the three divisions stand in the wakes one of another, and that those of the two other divisions are ranged on two parallel lines, and steer chequerwise. So that if it be wanted to change a fleet from the windward primitive order of sailing to this new order of battle on the other tack, the movement will be infinitely quicker than those which, in former known tactics, are commonly prescribed, to pass from all the orders of sailing either in one line, or on the obtuse angle of chasing or retreating, or in three or six divisions, to the usual order of battle. For it will be sufficient for the ships of the three divisions, ranged in the windward primitive order of sailing, to heave in stays all together, and get on the other tack in the opposite line of bearing, and they will instantly find themselves in this new proposed order of battle (fig. 59.); and should the fleet be in the leeward primitive order of sailing, it would be sufficient for the ships of the three divisions all together to haul their wind on the same tack as they steer, and they would find themselves in order of battle (fig. 60).

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Natural
and invert-
ed.

When the two columns *cd*, *ef*, are to leeward of the third division *ab*, ranged in order of battle, our author calls that the order of battle *natural*; and when *cd* and *ef* are to windward of *ab*, the fleet is in the order of battle *inverted*. The former of these orders is calculated for a fleet combating to leeward, and the latter for a fleet which must combat to windward.

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Advanta-
ges of these
orders of
sailing and
of battle.

That we may form some notion of the advantages which our author expects from drawing up a fleet for battle in the form of a lozenge, let us suppose the line *AB*, *CD*, *EF* (fig. 61.) to represent the fleet of an enemy to windward in the ordinary order of battle on the close-hauled line of bearing, and on the starboard tack. Then the leeward line *ab* will represent one of the divisions, in order of battle on the starboard tack, of the fleet ranged according to the new natural order, which the enemy wishes to attack, and to which he believes himself superior, because that division offers a front much inferior to his own. The two lines *cd*, *ef*, will represent the two other divisions standing on chequerwise on the same tack as the line of battle, and formed on the opposite close-hauled line. On this supposition, if the divisions *AB*, *EF*, of the hostile fleet, which have it not in their power to attack the ships of the line *ab*, wish to fall on the headmost ship *a* or the sternmost *b* of that line, they will be obliged to bear away in order to attack the two ships *a* and *b*. To prevent this, each of the divisions *cd*, *ef*, of the fleet ranged according to the new order, should make the following evolutions, according to their respective situations and to the manœuvres of the enemy.

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Evolutions
to be per-
formed
when en-
gaging,
and

1st, The ships of the division *ab* are to slacken as much as possible their headway, and form a very close line, till the enemy makes a movement to attack the headmost or sternmost ship of that division.

2dly, The ships of the division *cd* are to make sail till they come under the second or third ship of the rear of the line of battle *ab*, when they will take the same sail as the

ships of that division, to preserve that position until the hostile ships make their evolution to attack the rear ships of that division. In this situation the ships of the division *cd* will be able to observe the manœuvres of the enemy, in order to change tack and form themselves in order of battle on the opposite board as soon as the hostile ships shall have, after their bearing away, run over a certain space: because the ships of the division *cd*, steering afterwards close-hauled in the wake of the sternmost ship of the division *ab*, will be able to cover the rear ships of that division, and get the weather-gage of the hostile divisions which are bearing away; rake their ships; run alongside of them; double their rear-guard, and put it between two fires, if those hostile ships are following in the wake of each other (*c*); divide it if they bear away chequerwise, or gain to windward, and put between two fires the enemy's division *CD*, while it is engaged with the division *ab*.

3dly, The ships of the division *ef* may abandon their post and run chequerwise under a press of sail, in the same course and in the same order they were formed, as soon as they perceive that the enemy falls ahead of the division *ab*; in order that if the division *AB* of that enemy makes any manœuvre to bear away and fall on the division *ef*, or on the van of the division *ab*, they may, by going about, steer in order of battle close-hauled on the opposite line of bearing, and cover the headmost ship of the division *ab*, double the hostile division *CD* ahead, or divide the other hostile division *AB*, which is running chequerwise on the opposite tack.

The two divisions *cd*, *ef*, might again manœuvre another way, in case the ships of the enemy were ranged in one single line, not well formed, or should be in disorder and leave too great a distance between them while they are engaged very close with the division *ab* (fig. 62).

1st, By putting about the ships of the division *ef*, and likewise the ship *a* headmost of the division *ab*. 2dly, By making at the same time the ships of the division *cd* tack, and likewise the ship *b* of the division *ab*, to keep by the wind on the opposite close-hauled line. 3dly, By making all the ships of the division *ab* (which stood between the headmost *a* and the sternmost *b*) bear away four points at the same time, and making them also take the same tack as the ships of the other two divisions when they are on the beam of the sternmost ships of those two divisions; because, in that position, the ships of the two divisions *cd*, *ef*, getting to windward on two parallels in order of battle, in the wake of the two headmost *a* and *b*, might put between two fires a part of the enemy's ships, which then would be obliged to take the same tack as these two divisions, because the ships of the division *ab* (which are on the same tack as those two divisions) might prevent the ships of the enemy steering the course opposite to that tack.

From this succinct exposition it may be observed, that, in the first supposition, the way of thus disposing the forces of a fleet is so much the more suitable to the defence of the headmost and sternmost ships of a line of battle, as the ships of the division *cd*, being covered by that line of battle, are able to manœuvre without any one ship of that division being exposed to the fire of the enemy; that the division *ef*, the headmost ship of which is *e*, always presents the side to the

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er's Tactics.

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When the
enemy is in
a single line
not well
formed.

(c) If the hostile ships which are not engaged with any of those of the division *ab* bear away in succession in the wake of their headmost, in order to pass to leeward of the division *ab*, and to put it between two fires; then the ships of the division *ef* must necessarily take the weather-gage of them, since the headmost of that division *ef* is by her very situation already to windward of the headmost of the adverse ships which are bearing away, and she has the opportunity to come as close as possible to the sternmost ship *b* of the line of battle *ab*.

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er's Tactics.

the enemy, without any one ship of that division being exposed to receive the fire of the enemy either ahead or astern, because they are not to range in a line of battle unless the enemy runs large or before the wind; and that, in the second supposition, the only ships which are liable to be raked astern, while they change tack, are the headmost and sternmost of the division in line of battle which cover the ships of the other two divisions.

149
How to
know on
what tack
the fleet
must be
formed.

As it is of the utmost advantage to know, at first sight of the enemy, whether it be to windward or leeward of the fleet ranged lozenge-like, on what tack, and on what side the fleet must be formed, in order to defend itself or attack the enemy with advantage, it is to be observed, that in both the windward and leeward primitive orders of sailing the direction of the wind always traverses both the weathermost and leewardmost ships of the fleet (figs. 57. and 56.); that this leewardmost ship is always placed in the centre of an horizon, which is to be considered as the horizon of the whole fleet; and that it is from that ship you are to judge, by means of the rules which are known and practised in such cases, whether the lozenge-like fleet be to windward or to leeward of that of the enemy.

If you want to know, at sight of the enemy, seen either to windward or to leeward, on what side the line of battle is to be formed in order to be able to send one of the divisions on that side of the lozenge where there is none, it is the position of the enemy, with respect to the direction of the wind, which is to determine it; because, if the enemy is to windward of the fleet ranged in the windward primitive order of sailing, and if it bears down on that fleet, with the wind large or right aft, it belongs to its weathermost ship to observe what follows. If that ship, by setting the enemy, finds him to starboard of the direction of the wind, the division which is starboard of that direction of the wind is to take the starboard tack, and range in order of battle before the enemy is arrived within gunshot: if, on the contrary, the above-mentioned ship finds the enemy to larboard, it belongs to the larboard division to assume the order of battle, and to take that tack, before the enemy can come to action. The old rule for choosing the proper tack is to be observed by a fleet in the leeward primitive order of sailing; observing, that it is the business of that fleet's leewardmost ship to determine it; and the point of the horizon which is opposite to that whence the wind blows, is the point towards which the observer is to be turned to judge on what side, whether starboard or larboard, the line of battle is to be formed; because, in that position, the starboard side must always be on his right hand and the larboard on his left.

By following this general rule, the line of battle will never be exposed to be too much lengthened either to windward or to leeward, in order to oppose all the ships of the adverse fleet formed in one single line, nor even to be surprised in disorder by that fleet while you are forming in orders of battle natural or inverted.

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The orders
of chasing,
retreat, and
convoy.

Our author's orders of CHASING, of RETREAT, and of CONVOY, are very easily formed. We have already said what they are; and the seaman, or even the landsman, who has any tolerable conception of his orders of SAILING and of BATTLE, will not stand in need of any farther description of them. It must, however, be observed, that in the order of chasing, the fleet in the lozenge-like position presents the obtuse angle of chasing, as when ranged according to the ordinary tactics; with this difference, that, in order to form themselves in order of battle, it is enough that, in this lozenge-like position, the ships of the second division should all keep the wind on the same board they were standing on, because they would afterwards find themselves in a line in

the wake one of another; but, according to the usual tactics, the ships have a long space to run before they can execute the same evolution.

We shall conclude this short view of the Viscount de Grenier's tactics, with his directions for the most advantageous placing of the admiral's ship, the frigates and transports, belonging to a lozenge-like fleet, whether it be ranged in the order of sailing or of battle, &c.

In the order of sailing, the admiral A is to be placed ahead of the fleet, at a short distance from the headmost of the second division, and in the direction of the wind with the headmost of the first division (fig. 63.). Two of the frigates ff are to observe the same rule and the same position, with respect to the van ship of the third division and the sternmost of the first. In the order of battle, on the contrary, the admiral is to be in the centre of the lozenge, and two of the frigates on the fourth side of the lozenge, (fig. 64.). As for the transports and store-ships, when there are any, their station is to be in one line on the side opposite to that of the enemy, when ranged in order of battle; and, if in order of sailing or convoy, they may occupy the space circumscribed by the lozenge. In any other circumstances these ships are to occupy the different stations appointed for them, that they may distinguish the signals and execute the commands of the admiral. Lastly, when the fleet shall pass from the order of battle to any other order whatever, or from any order to the order of battle, the admiral's ship is to bring to, and not to take any of the positions above mentioned till after the complete execution of the movement.

CHAP. II. *View of Mr Clerk's Tactics.*

WHETHER the Viscount de Grenier's order of battle and of sailing would be attended with all the advantages which he hopes from them, experienced seamen alone can judge; but we are now to introduce to our readers part of a system which has met with very great approbation from some of the ablest officers in the British navy, and which to us appears to be founded on principles self-evident. Mr Clerk, in the introduction to his Essay, informs us, that upon considering the great superiority displayed in the three last wars by the British seamen over their enemies, when engaged in single ships, and comparing it with the very little that, previous to Lord Rodney's glorious action, they had achieved when engaged in fleets drawn up in line of battle, he was led to conclude, that there must be something wrong in our mode of making the attack. He turned his thoughts to the subject, and in 1790 published part of a large work, comprehending, 1. *A Theory of Attack from Windward*; 2. *A Theory of Attack from Leeward*; and, 3. *An Historical Sketch of Naval Tactics*. We think it not much to the honour of our countrymen, that he has not yet had encouragement to publish more than the first part; but in hopes of exciting their curiosity, we shall lay before them a distinct view of that part, beginning, as he begins, with

OBSERVATIONS ON THE PRESENT METHOD OF BRINGING SHIPS TO ACTION.

It has often, if not generally, been the practice, in the case of single ships, as well as in that of fleets, for the weather ship or fleet, when it is wished to bring the other to action, to steer directly down upon that ship or fleet, without reflecting that, by doing so, it gives the enemy an opportunity of completely disabling it, before it can attain its wished for station. For each ship in the lee line can use all the guns upon one side; whereas the ships in the weather-line,

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How the
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ship, the
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ports, are
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bearing
down di-
rectly on
the enemy.

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ther-line, bearing directly down, have it only in their power to use their bow-chases. This method of attack appears, therefore, to be the worst possible for the weather-fleet, and the most advantageous for the lee fleet. For suppose a single ship of 80 guns to windward at B (fig. 65.), discovering an enemy's ship of equal force to leeward at F, to bear directly down upon her endwise, the receiving ship F, by lying to as in fig. 66. would present a broadside of 40 heavy guns bearing upon B during a course of two miles, in which every shot might take effect; while B, in this position, would have it in her power to bring only the two light guns of her forecastle or bow-chase to bear on F; a disadvantage greatly exceeding twenty to one. Besides, the receiving ship F, by lying broadside to, will have all her masts and rigging more open, and consequently will allow shot to pass with less effect than the ship B, which, coming endwise, is liable to be raked by every shot from stem to stern. The consequence of which must be, that B would be disabled in her rigging, &c. long before she could arrive at a proper position for annoying F; and when she had attained that position, F, by being entire in her rigging, would have it in her power to fight in any position, or to make off at pleasure.

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Proper method of attack.

The method then is, B having the wind, should run down astern, as *per* dotted line, and getting into the course, or near the wake of F, or a position that will bring her parallel to the course of F, at a proper distance, she should then run up close alongside of F, upon equal terms, as in fig. 67; or otherwise, on shooting ahead, she may veer, and run down on the weather-bow of F, as in fig. 68. till she shall force F to bear away to leeward, keeping close by F on equal terms; but during the course, in both cases, carefully watching that F may not have it in her power to bring her broadside to bear upon B without retaliation.

154
Modes of attack by the British and French.

It having been often said that the French have made it a rule to throw the whole effect of their shot more particularly into the rigging of their enemy, and that the British, on the other hand, have been as attentive to point the force of their fire against the hull of the ship; it may be proper here to state the two cases, and compare the effect.

Let us suppose a ship of 80 guns wishing to avoid the effects of a close engagement, but at the same time lying to as at F (fig. 63.), intending to receive, with every advantage, an enemy B of equal force, coming down with an intention to fight her; and let us suppose that F, by aiming her fire at the rigging of B, shall have carried away any of the principal stays, eight or ten windward shrouds, or a fore-topmast, or any other rigging, though of much less consequence, but, at the same time, without having wounded a single man of the ship B; and suppose a second ship, consort to F, receiving such another ship as B, and by firing at her hull only, shall, without other damage, have killed 30 or 40 of her men: In this critical juncture, when F and her consort are desirous of avoiding a close engagement, it is evident that the ship at B, which has lost part of her rigging, is more completely disabled from closing with them than the other ship, whose rigging is entire, though she may have lost 100 of her men.

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No ship in the line of battle can be exposed to the fire of many at once.

It has been often said, that some particular ship has been exposed in battle to the cannonade of three, four, or even five ships, all extended in the enemy's line, and all bearing upon her at one and the same time; but this can never have been the case, but when the ship so exposed was at a very great distance. Let I, H, F, H, I, (fig. 70.) represent five ships extended in line of battle ahead at the distance of one cable's length, or 240 yards, from each other; let the length of each ship be 40 yards, so that the whole space between head and head of any two adjacent ships is 280

yards; and let the perpendicular line FK, proceeding right out from the beam of the middle ship F, to the distance of six cable's length or 1440 yards, be divided into six equal parts: It is evident, from inspection, that a ship stationed at the point E of the line FK, 720 yards distant, cannot for any length of time be exposed to the fire of more than the centre ship F or the fleet I, H, F, H, I. For supposing the ships H, K, ahead and astern of F, to be able to bring their broadsides to bear on E (a supposition which, if the line be close-hauled, cannot be made of the headmost of those ships), it is evident, that by putting themselves in positions proper for that purpose, the ships H, H, will not only disorder their own line, but also leave, the one her head, and the other her stern, exposed to a raking fire from their opposites B, B, in the enemy's line.

But if the opponent ship cannot well be exposed to the fire of the two ships H, H, at the point E, she must be still less exposed at the point C, 480 yards distant; and it will be almost impossible for the ships H, H, to touch her at the point G, 240 yards, or one cable's length, distant.

But one cable's length asunder is too small an allowance for accidents that may happen by the ships I, H, F, H, I, extended in line of battle ahead. Therefore let us suppose the three ships, which are said to be at once upon a single opponent, to be stationed at I, F, I, at the distance of two cable's length or 480 yards from each other. Then it is evident that the opponent ship cannot now be more exposed at the point K, at the distance of 1440 yards, than she was, on the former supposition, at the point E, 720 yards distant; and if we suppose the line of battle to be formed at one and an half cable's length asunder, she must be at L, distant 1080 yards, before she can be annoyed even to this degree by the three hostile ships at once. Hence we may fairly conclude, that if one ship has any time been exposed at once to the fire of five, four, or even three ships of the enemy's line, such ship must have been at a very great distance, and in no great danger.

Having finished the above observations, our author proceeds to the principles necessary to be known for enabling us to judge of the different modes of bringing great fleets to action. For this purpose he supposes a fleet of 10, 20, or more ships, of 80 guns each, extended in line of battle to leeward, and lying to at F (fig. 71.), with the intention of avoiding an attack; whilst another fleet at B, of equal number and force of ships, also extended in line of battle, three or four miles to windward, is desirous of making an attack, and coming to close action on equal terms with the fleet F. In this disposition of the two fleets, should that to windward run down headlong ship for ship on its opponent, as in figs. 66. and 69. it is evident, from what has been said in the beginning of this chapter, that each individual ship of the weather-fleet might be completely disabled before it could possibly come to close action with the fleet to leeward. But let it be supposed that the commander of the weather fleet B, though his ships have been much disabled in their rigging during their course *aaa* from windward (fig. 72.), has made them bring to at a great distance, from whence he can hurt F; is it to be expected that F, whose desire has always been to avoid a close engagement, and who has already disabled the ships of B, will patiently lie still, or wait until B shall have time to disable him in his turn? No surely. While enveloped in his own smoke, as well as that of his enemy, he will bear away unhurt to a new station G, and there remain out of the reach of B's cannon-shot, who must repair his rigging before he can attempt a second attack.

Again, suppose that B, in place of going headlong and endwise down, were to run down in an angular course, or *lasking*

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lasking as it has been called; it is evident from fig. 73. that should any ship in this angular line come to be crippled, her way being stopped, might of consequence occasion a confusion amongst the ships next astern to her, some running to leeward and others to windward of the disabled ship; and thus the time be lost for affording the necessary support to the ships ahead, and now so far separated from their companions. Should it be said, that a stoppage of one ship ahead will not necessarily produce a stoppage of every ship astern, because they may go to leeward of the disabled ship; we answer, that the ships ahead in the van A (fig. 74. n° 1.) may be now engaged, and of consequence not having much headway, may be said to be stationary; therefore every ship astern, if she shall attempt to bear down, as at D, D, from being confined to a determined course, must be brought into the position of being raked when coming down before the wind, as in figs 76. and 69. and consequently of being completely disabled long before she can get close enough alongside of the enemy.

Again, the headmost ships, or van of B, having attained their station at A, that is, abreast of the van of F (fig. 74. n° 1.), and having begun the cannonade, may we not suppose that F, whose conduct or desire has always been to save his ships, has instructed the commanders of those in the van of his fleet to withdraw from danger as soon as they begin to feel the effects of a cannonade? and if so, may not those ships, as soon as they have thrown in their fire upon the van of B, bear away in succession as at H, followed indeed by the whole ships of F's fleet, which, having poured in their fire upon the van of B, may form a new line of battle two or three miles to leeward at II (fig. 74. n° 2.), and there be in readiness to receive a second attack, if B shall be so imprudent as to attempt it? And is it not farther evident, that if any one or more ships of the Squadron of F shall be crippled, they will have it in their power to quit their station, being covered with smoke, at any time, and to fall to leeward as at G, where they will be in safety?

Plate
ccccxcix.

In order to illustrate this still farther, let B (fig. 75.) represent a fleet putting before the wind, each ship with an intent, when brought to at a determined distance at A, to take up her particular antagonist in the line of the enemy F to leeward; and, for argument's sake, let F be supposed at rest, without any motion ahead. There seems to be no difficulty in conceiving, that while the alternate ships of F's line, under cover of the smoke, withdraw from battle to GGG, the intermediate ships left behind them in the line will be sufficient to amuse even the whole of B's fleet, till the ships G shall form a new line HHH as a support from the leeward. In such case B, after being disabled, as he must be, and not having foreseen the manœuvre, will neither be able to prevent the intermediate ships with which he is engaged from bearing away to join their friends, nor, were he able, would it be advisable to follow them; for the same manœuvre with equal success can again and again be repeated.

In order to show the relative motion of both fleets, let F (fig. 76.) be a fleet consisting of twelve ships, drawn up in line of battle, at one cable's length or 120 fathoms asunder; and let the length of each ship from the end of the jib-boom to the stern be 36½ fathoms; the whole fleet will then occupy a space of two English miles; also, let its rate of sailing be four knots an hour in the direction FG, so that in the space of an hour it may have moved from F to G four miles distant from its former position.

Let B be the opponent fleet, consisting also of twelve ships, and four miles to windward; and let the point A be 440 yards, or one quarter of a mile, right to windward of

the point G. Then if B, by bearing away in the direction BA, shall arrive at the point A at the same instant that F, the fleet to leeward, has arrived at the point G, the motion of the fleet B will have been at the rate of 5½ miles nearly per hour; and the angle contained between the direction of its line of bearing and present course 43° 9', or nearly 4 points. For in the right-angled triangle ABM are given BM = 4 miles, and AM = 3½ miles. Now BM = 4 m. : AM = 3½ m. :: R : tan. ABM = 43° 9', and R : sec. ABM. 43° 9' :: BM = 4 m. : AB = 5.483 m.

Again, if F, as in fig. 77. by carrying more sail, shall move at the rate of six miles an hour, that is, from F to G; then B, having his course made thereby the more slanting, will have just so much the greater difficulty of keeping his ships in line abreast while coming down to the attack: For the leading ship meeting with no obstruction in her course, will push on; whereas every accident of obstruction accumulating, as it happens to each ship progressively, the rear, being affected in the greatest degree, will for that reason be left the farther astern. But, from the very form of this slanting course, every ship astern will be apt to get into the wake of the ship ahead. Therefore the whole fleet of B, van and rear, will not arrive in the same time at the line AD, so as to be in a perfect line abreast, and parallel with the fleet to leeward; but will have assumed the lasking form, as represented at the points M, N, and O, in the different parts of the course. In this case, the distance run by the van of B, from B to A, is 7,075 miles, or 7 miles and 132 yards, and the angle contained between the line of bearing and the distance BA is 32° 0'.

And again, as in fig. 78. if the fleet to leeward shall lie up one point higher, as FG, then the rears of the two fleets will thereby be removed at a much greater distance, and the van A of consequence must be sooner up with the enemy's van, and evidently so much the farther from support; while F, by bringing up his ships in succession, will have it in his power to disable the van of A, and will afterwards bear away, as at H, unhurt and at pleasure; while B, at this time, by the supposition, being crippled, or having his rear D obstructed, and at a distance, will be unable to prevent him. And in all the three cases, it is evident that the fleet B, so soon as he shall approach within reach of gun-shot, must be exposed to the fire of F's whole line; for he will be abreast of B continually in every part of his course. But the difficulty of bringing the rear of the windward fleet to action will still be more increased, if the sternmost ships of the fleet to leeward, in place of keeping their wind, shall bear away occasionally as at ML. All which being admitted, the difficulty of bringing adverse fleets to close engagement may be accounted for, without being obliged to have recourse to that supposed inferiority in point of sailing, imputed to our ships, compared to those of the French our enemy.

Hence it appears, that a fleet B to windward, by extending his line of battle, with a design to stop and attack a whole line of enemy's ships to leeward, must do it at a great disadvantage, and without hope of success; for the receiving fleet F to leeward unquestionably will have the four following advantages over him: 1. The superiority of a fire above 20 to 1 over the fleet B, while coming down to attack. 2. That when the ships of B are brought to at their respective station, if it blows hard, the shot from F, by the lying along of the ships, will be thrown up into the air, and will have an effect at a much greater distance; whereas, on the other hand, the shot from B, from the same cause, will be thrown into the water, and the effect lost. 3. That F will have the power of directing and applying at pleasure the fire of his whole line against the van of B, who is now

View of
Mr Clerk's
Tactics.

unable to prevent it, his ships being disabled, separated, and therefore unsupported. 4. That F will also have a greater facility of withdrawing from battle the whole or any one of the disabled ships of his line.

If then, after a proper examination of the late (D) sea-engagements or rencounters, it shall be found that the French admirals have never once shown a willingness to risk the making of the attack, but invariably have made choice of, and earnestly courted, a leeward position; if invariably, upon seeing the British fleet disabled, they have made sail, and demolished the van in passing; if invariably, upon feeling the effect of the British fire, they have withdrawn at pleasure either a part or the whole of their fleet, and have formed a new line of battle to leeward; if the French repeatedly have done this upon every occasion:—and, on the other hand, if it shall be found that the British, from an irresistible desire of making the attack, as constantly and uniformly have courted the windward position; if, uniformly and repeatedly, they have had their ships so disabled and separated, by making the attack, that they have not once been able to bring them to close with, to follow up, or even to detain one ship of the enemy for a moment—shall we not have reason to believe, that the French have adopted and put in execution some system which, if the British have discovered, they have not yet profited by the discovery?

Our author therefore, instead of the usual mode of attack, which, by being made principally on the van, seems to be the result of a groundless expectation of being able to *take, destroy, or disable* the whole of the enemy's line, proposes

A NEW MODE OF ATTACK FROM THE WINDWARD UPON THE REAR OF THE ENEMY.

157

Mr Clerk's
mode of at-
tack upon
the rear of
the enemy.

Suppose, says he, a fleet of ten, twenty, or more ships, extended in line of battle at F (fig. 79.), endeavouring to avoid a close engagement, but at the same time keeping under an easy sail, with the intention of receiving the usual attack from another fleet of equal number, three or four miles to windward at B, sailing in any form, but let it be in three lines or divisions; it is required by what method shall B make the attack on F with advantage?

The improbability, or rather impossibility, of attacking and carrying the enemy's whole line of ships, having been demonstrated by every action which has been fought at sea, the next consideration will be, how many ships may be attacked and carried with advantage? Let it be supposed that the three sternmost ships only, and not exceeding the fourth, are possible to be *carried*; let a sufficient strength A be sent down to force an attack upon these three ships, disposed and supported according to the judgment of the admiral, while in the mean time he keeps to windward with the rest of his fleet, formed into such divisions as may best enable him to attend to the motions of the enemy and the effect of his attack; being himself so far disengaged from action, as to be able to make his observations, and give his orders, with some degree of tranquillity.

By placing the fleet B in such divisions as represented in the figure, when the attacking squadron comes up with the rear of the enemy, the whole will be so disposed, and so connected together, as to be able to give the support and attention that may be required to any ship, or any part of the fleet, and in preference to a long extended line of six or

seven miles in length, where it must be impracticable to give the necessary support to such ships as may be disabled. The ships of the fleet F may, in general, be better sailers than the ships of the fleet B; but it is not conceivable but that the swiftest ships of B must come up along side of the sternmost and dullest sailing ships of the enemy F; while, at the same time, F, by attempting to out sail B, must be thrown into the disorder of a downright flight: Therefore, of course, it must be admitted, that if the enemy F continues going off in line of battle, and endeavouring to avoid a close engagement, it will be impossible to prevent the fleet making the attack from getting into the position B A. But by this position, it is evident that the three ships at I of the fleet F will be in the power of the admiral of B; for, by keeping so many ships to windward, he will be enabled to send down fresh ships from time to time, either for the support, or to supply the station, of any of those that may be disabled in making the attack, while it may be imagined that the three ships in question, by being disabled, or being deprived of the wind now taken out of their sails by the ships to windward, will be prevented from following their friends. Hence the enemy ahead must either abandon his three sternmost ships, or he must double back to support them; which must be done either by tacking or veering. But let it be first examined what is naturally to be done by tacking; and for the greater satisfaction, let every possible case that can happen be examined separately.

First, let us suppose that the enemy at F, fig. 80. has continued to protract his course in line of battle upon the same tack, and that the headmost ship H, with the three next astern of her, have tacked to windward, and that the whole remaining ships intend to tack the same way, but in succession; is it not evident that F has then left his three sternmost ships at I in the power of the ships at A; that he must also leave exposed his fourth and fifth ship G to another attack from another division of B at C, which will also be on equal terms as with his three sternmost at I; and lastly, if he prosecutes his intention of supporting his three ships, he will be obliged to begin a disadvantageous attack upon the admiral, with the main body of the fleet lying ready to receive him? The consequence of all which must be, that he will not only lose his three sternmost ships, but in all probability the fourth and fifth also, as at G; and will be forced to begin an attack, and close and mix ship with ship on equal terms; a situation which he at all times, with the greatest anxiety, hath avoided, and which B with equal anxiety has always courted.

Again, suppose that his three sternmost ships have been attacked, and that he has ordered his fleet to tack all at one time, as in fig. 81. The consequences will then be, that this movement, having required some time and some length of course, will have produced a considerable distance between his main body and his three ships; or, in other words, that these three ships have been deserted; for it will not be in their power to tack with the rest of their friends. He must also, in bringing his ships heads round, expose the ships nearest his enemy to be raked by a dreadful cannonade; besides running the risk of having his fleet thrown into a general disorder, by many of his ships missing stays, veering, and running to leeward. Lastly, upon a supposition that his ships have all tacked, and none of them missed stays, still he

(D) This was written during the American war, and before Lord Rodney's decisive victory on the 12th of April 1782. That action, as well as the still more brilliant one of Lord Howe on the 1st of June 1794, we have heard the author distinguish from those battles which, with great propriety, he calls *sea-rencounters*, and do ample justice to the scientific manœuvres of both the noble admirals.

View of Mr Clerk's Tactics. he must of necessity begin the attack, mix his ships, and come to a close engagement, as in the former case.

160 The enemy's attempt to support his three sternmost ships by veering his fleet.

Having shown the consequences of an attempt to succour the three sternmost ships by tacking, let us also examine what may be expected from an attempt to do it by veering the fleet. Suppose the two fleets in the same position as in fig. 79. that is, the main body of the enemy extended in line of battle to leeward, his three sternmost ships entangled with the fleet B, whose admiral, with the main body, keeps to windward to observe, with a rigid attention, the motions of the enemy. At the same time suppose that the admiral F has ordered his sternmost ship G to veer (fig. 82.), and afterwards the whole line; and that he is now running upon a contrary tack to leeward, as at H, wishing to support or bring off his three ships. From inspection, it will be evident that this attempt may be more dangerous than the attempt to windward; for it will expose a number of his ships to a raking fire while in the act of veering; and the squadron, by getting so far to leeward, will be unable to give the proper support to the three ships. It will open a gap for the fleet of B (who will immediately veer also and follow him) to break in, as at A, and cut off the three ships without hope of recovery. And if F shall still persist in the endeavour to recover his three ships, he will be obliged to begin the attack under all the usual disadvantages.

Again, upon another supposition, that the headmost ship of the enemy H (fig. 83.), with the four or five next astern, have wore, and are running upon a contrary tack, wishing, as before, to support or bring off the three ships, the rest of the fleet intending to wear also, and follow in succession; it is evident that this movement, being more unseaman-like, will be worse than the last: It will expose an additional number of ships, particularly the last two, as at G; and will at the same time make an opening for the main body of B's fleet to fall in and cut off the three ships, as in the former case.

Again, should the enemy F veer and bear away with his whole ships at one and the same time, it is evident that this movement must have the consequence of a downright flight, with the certainty of losing the three ships.

From what has been said, it will appear, that a fleet B, keeping connected in a body to windward, may come up with and entangle the three sternmost ships of an enemy F, extended in line of battle and going off to leeward, and at the same time be able to overawe the remaining main body of their fleet; and that, having forced the position, the whole consequences, as already described, must follow; that is, F must submit to the loss of three ships.

What has been hitherto said proceeds upon a supposition that the fleet F has kept on his course till the fleet B has come up with his rear. Let it then be examined what other attempts the enemy F can make to avoid coming to close engagement upon equal terms.

161 The enemy endeavouring to avoid the attack upon his rear by veering and passing on contrary tacks to leeward. Suppose a fleet of ships of the enemy standing on the larboard tack to leeward, and going off as before at F, and a fleet of ships in a collected state or position to windward, as at B (fig. 79.); and suppose that the enemy F, perceiving the fleet B pointing an attack against his rear, in place of keeping on his course upon the same tack, should veer, and endeavour to pass on contrary tacks to leeward (for it will not be admitted that he can get to windward); what will then be the effect?

Is it not evident, that the headmost ships of F must be forced to leeward by the fleet B obstructing his line of direction, or the line of his course? that they must be forced to begin an attack at any distance B may choose? that they may receive such damage as will stop their way? that their way being stopped, will of course be an obstruction to

the next astern; or that these subsequent ships, to prevent this stop, must bear away to leeward of their crippled ships, as at G (fig. 84.), which will not only prevent these ships from damaging the headmost ships of B, but will give time and opportunity to B to bring down his windward ships to fall in either ahead or astern, that is, to the right or left of his headmost ships A, and oppose ship for ship of the enemy upon equal terms? But should none of the headmost ships of the squadron F be crippled, that is, should F pass B without reach of cannon-shot, which undoubtedly he will do if he can; still, while bearing away, he may be forced to suffer a distant cannonade, ship with ship on equal terms, whether he veers and gets back upon his former tack, as at G in fig. 85. or continues to run before the wind, as at P in fig. 86. But if F persists to pass on a contrary tack to leeward, and without reach of cannon-shot, it is evident, whether he put right before the wind, or run off ship by ship as he best can, that B must at some time or other come up with his rear.

162 Effect produced by a change of wind during the action. So far the attack has proceeded with the wind fixed in one and the same quarter. To make the propriety of it the more apparent, it will be necessary to inquire, What might be the effect produced by a change of wind, should that take place during the action? For this purpose, let the opponent fleets be placed in some one of the preceding positions, representing the attack upon the three sternmost ships of the enemy, as in fig. 87.; in which the fleet desirous of making the attack is represented in four divisions, as at B, B, B, A, and F the fleet desirous of avoiding the attack, at the hazard of abandoning his three sternmost ships at G.

163 The wind shifting by degrees, and coming aft. In the commencement of the attack, let us suppose the wind to be N. and the ships going two points free on the larboard tack, or standing E.; and soon after the commencement let the wind be supposed to veer round to the W.; then it is evident, by the disposition of the two fleets, that the fleet F, by such a change, will have acquired no advantage whatever; on the contrary, it will thereby be thrown just so much the farther to leeward.

164 The wind shifting by degrees round ahead. Again, if the wind, by taking an opposite course, shall shift ahead and come round by the eastern quarter to L, the admiral of the fleet F will not have it in his power to avail himself of this circumstance, provided the commander of B, continuing carefully to watch his motions, and feeling the impulse of the veering wind, shall stretch his ships, as at OO, to the windward of the three ships at G, separated from F's fleet, and at the same time to the leeward of the main body of that fleet. This will be apparent from figures 88. and 89. which exhibit the two fleets, after this manœuvre, both on the larboard and starboard tack.

165 The wind continuing to veer round the compass. Let the wind be supposed to wear round gradually from the E. towards the S. and from thence to the W. and then quite round the compass. Then F being supposed to have gained the wind, it will be in his power to maintain it, and make a circular course to windward of B; but as he can be attended all the while by the fleet B, who will cut him off to leeward, he never will be able to recover his three ships, supposed to be cut off. This is evident without the illustration of a figure.

166 The wind shifting instantly to the opposite point. Lastly, if the wind in changing shall in one instant shift in direct opposition where it was when the attack began, that is, from north to south; then and in that case, before it can be judged whether such change shall be favourable for F or not, it will be necessary that the relative situation of the two fleets should be determined, such as it was when the change took place. For example, if the headmost ships of the fleet F, that is, if his van and centre shall have separated at any considerable distance from his rear, and shall, in

Partial
Breezes of
Wind.

consequence of this mode of attack, have advanced to a position as represented in fig. 90. it is evident that F, though by this change he shall have got to windward, will yet not be able to avail himself of this seeming advantage, the fleet B having it still in their power to cut him off from his three ships.

On the other hand, if this instantaneous change of wind, in direct opposition, shall have taken place more early in the action, that is, when the positions of the two fleets shall be such as represented in fig. 87. (the fleet B in the position of four divisions B, B, B, and A, and the enemy in the positions F and G); then F, who before was to leeward, by this instantaneous change of wind from the north to the south, having now got to windward of every division of the fleet B, is it not evident that it may be practicable for him to carry assistance to his three ships at G in the rear, and perhaps even to cut off some of B's ships at A, if they do not with all convenient speed bear away to put themselves under the protection of their friends B to leeward? But whether F shall attempt to effect this manœuvre, by veering his ships in the line, or, what seems most eligible, by making his ships tack, as it is to be presumed that his three ships, which have been some time engaged, must be considerably crippled, and not able to make sufficient sail; while endeavouring to bring them off, it will be difficult for him to prevent being drawn into a general and close engagement, which, by the supposition, he has all along endeavoured to avoid.

CHAP. III. *Of Partial Breezes of Wind.*

It often happens at sea, that when two ships are in sight of each other, one of them will be sailing at a considerable rate, being favoured with a breeze of wind; while the other at the same time is lying becalmed, having no other motion than what she receives from the tide or a current, if any, or from the swell of the sea. As this may be the case with respect to two adverse fleets when in sight of each other, that fleet which has the advantage of the wind will evidently use every possible method to prosecute the advantage that may result from it. Thus if the fleet desirous of making the attack be favoured with a breeze of wind, while the other fleet at the same time is lying becalmed, it is evident that the commander of this fleet will endeavour to get as near the opponent fleet as possible; whereas, if the fleet wishing to avoid an engagement be favoured with the wind, the other lying becalmed, then that fleet will avail themselves of this opportunity of making their escape.

If the attack upon the three sternmost ships shall have commenced before this partial breeze in favour of the fleet pursued has taken place; then the variety of positions in which the two fleets may be affected is so great, and the resulting consequences so numerous, that it would be an endless task to give a separate description of each. In the meantime, therefore, as it is imagined nothing in such investigation will be found that can materially affect the general issue; and since no breeze whatever can favour the fleet F, so as to enable it to sail round and round the fleet B, which all the while is supposed to be lying becalmed, it will not be too much to say, that *this partial breeze in favour of the fleet F, taking place after the attack began, although it may facilitate the escape of his van and centre, will not avail him much in the recovery of the three ships in his rear*—perhaps not in any case as yet exhibited, excepting this one, where the wind in one instant had changed in direct opposition.

Now let, as formerly, the attack be commenced before the partial breeze in favour of the fleet pursued has taken place,

but that the wind has instantaneously shifted in direct opposition; then, even in this case, the same breeze which would favour F (fig. 87.) in the attempt to bring off his three ships, would at the same time favour the escape of the ships of B at A, as formerly described. That this partial breeze would require to be of considerable duration, otherwise F, in thus attempting to bring off his three ships, crippled as they will be, must hazard a general engagement, in like manner as already described.

Mr Clerk employs a section of his book to show the propriety of his proposed attack from windward, in places where the hostile fleets are liable to encounter winds blowing in contrary directions at the same instant; but as this is a case which does not surely often happen, we shall refer our readers to the work itself, and conclude this article with some other methods of attack, which have been suggested as improvements of that which is commonly followed.

1st, It has been proposed that the attack should be made with the greater part bearing down before the wind upon the six sternmost ships of the enemy. It is, however, evident, that ships by making the attack in this manner must be exposed, without a possibility of return, to as many broadsides from each of these six ships as can be got ready during a course of two miles. Hence, as the ships making the attack will assuredly be disabled before they can have it in their power to hurt the enemy, this mode of attack cannot be proper.

2d, It has also been imagined, that some part of the force chosen to make the attack should be sent to leeward as well as to windward of the three ships determined to be attacked. But the danger supposed, of shot passing over the enemy's ships, and striking those of friends, may be an objection to this mode.

3d, Others have been of opinion, that the headmost ship chosen to make the attack should come close up alongside of the sternmost of the enemy, and having delivered her fire, push along the line as far as possible, which may be supposed to be the sixth ship of the enemy; and as it is evident that this first ship may have received six broadsides, that is, a broadside from every one of the six ships of the enemy during her course in passing them, it has been thought possible that the other five ships, by following close after her, may attain their stations, each abreast of her opposite, without having received a greater number of broadsides than they have had it in their power to return; and therefore that by this mode the number of ships to be attacked will be determined: For as many ships as the leading ship will be able to reach, as many will the attacking fleet be able to carry.

4th, Again, let it be supposed, as in the former case, that the fleet making the attack has been brought up to action in a collected manner, but subdivided only so far as the service may require, and that the leeward division shall be more particularly destined for the immediate attack, while, at the same time, the body of the fleet keeping to windward shall be supposed attentive to give the necessary support where required; then let it be supposed, that the headmost ship making the attack having been soon crippled, shall not have been able to push farther than the third or fourth ship of the enemy's line—is it not easy to conceive, it is asked, that some one or more of the ships to windward, attentive to support and supply her place, may bear down on the fourth ship of the enemy, under cover of the smoke, throw in her fire, and push on to the fifth or sixth ship, or perhaps farther; and that so far as this fresh ship, or a second fresh ship, may be able to push, so many ships of the enemy may be expected to be carried? For whatever ships of the enemy can

Partial
Breezes of
Wind.

169
The wind
shifting in-
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ously in di-
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tion.

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Of some
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The fleet
pursued be-
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the attack
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168
Of little ad-
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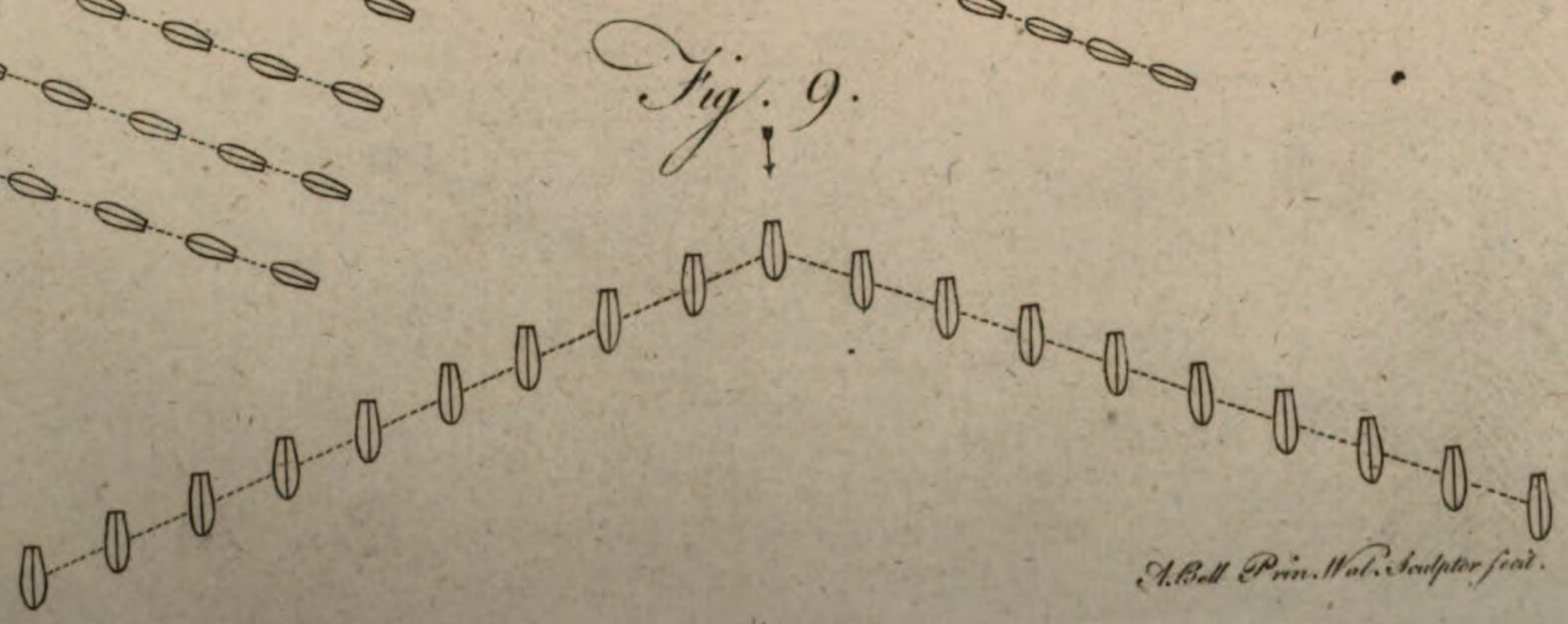
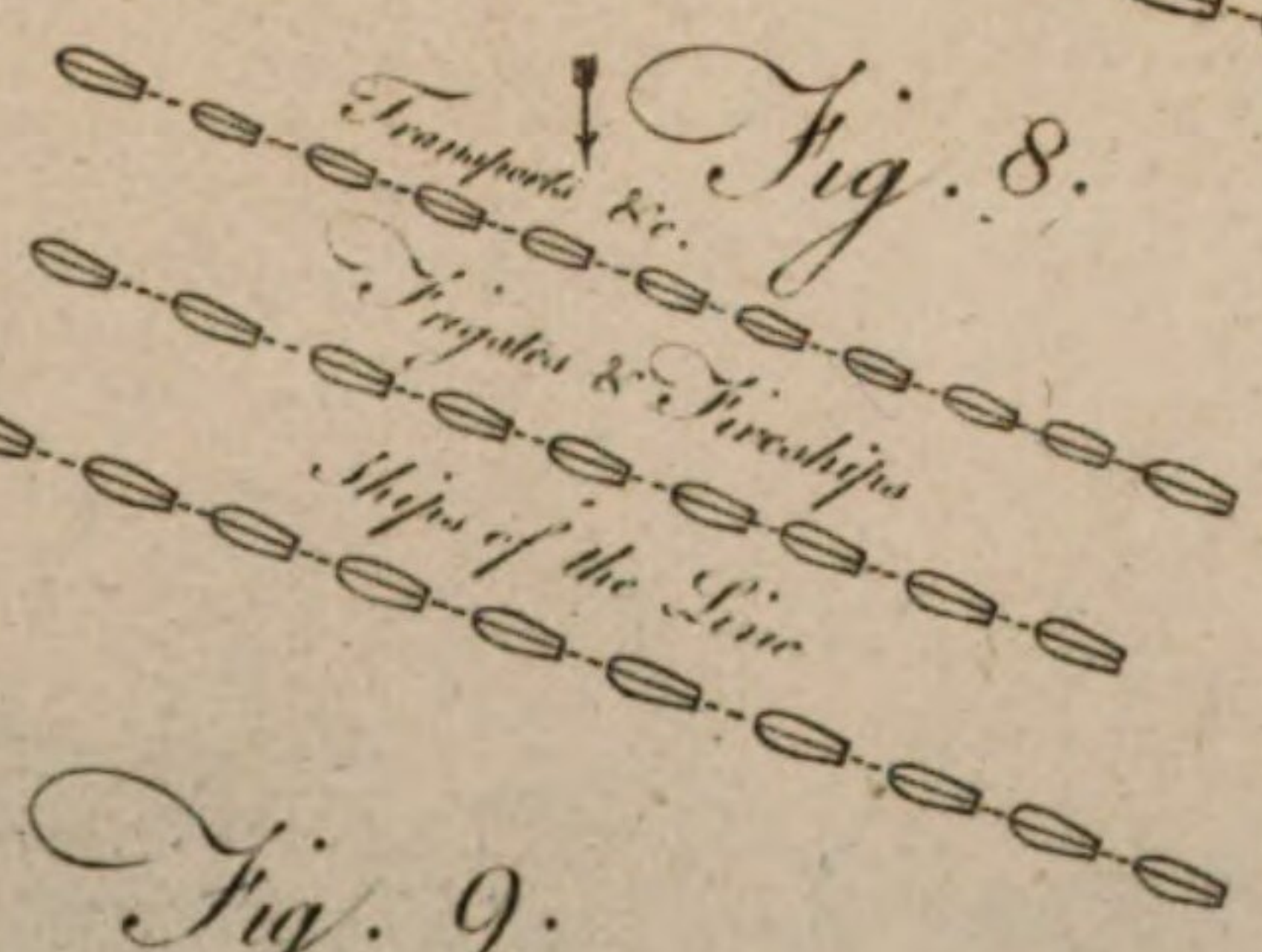
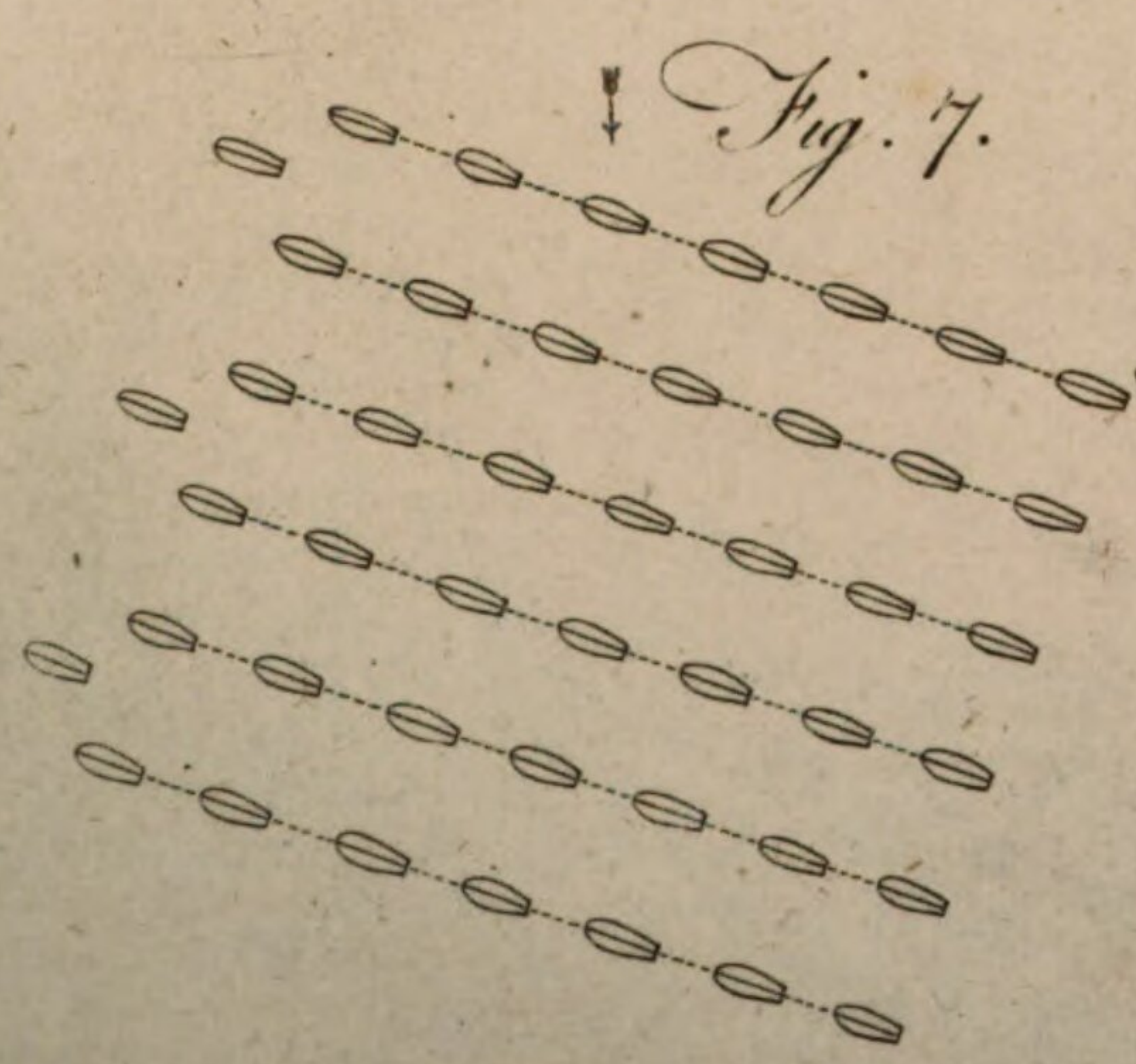
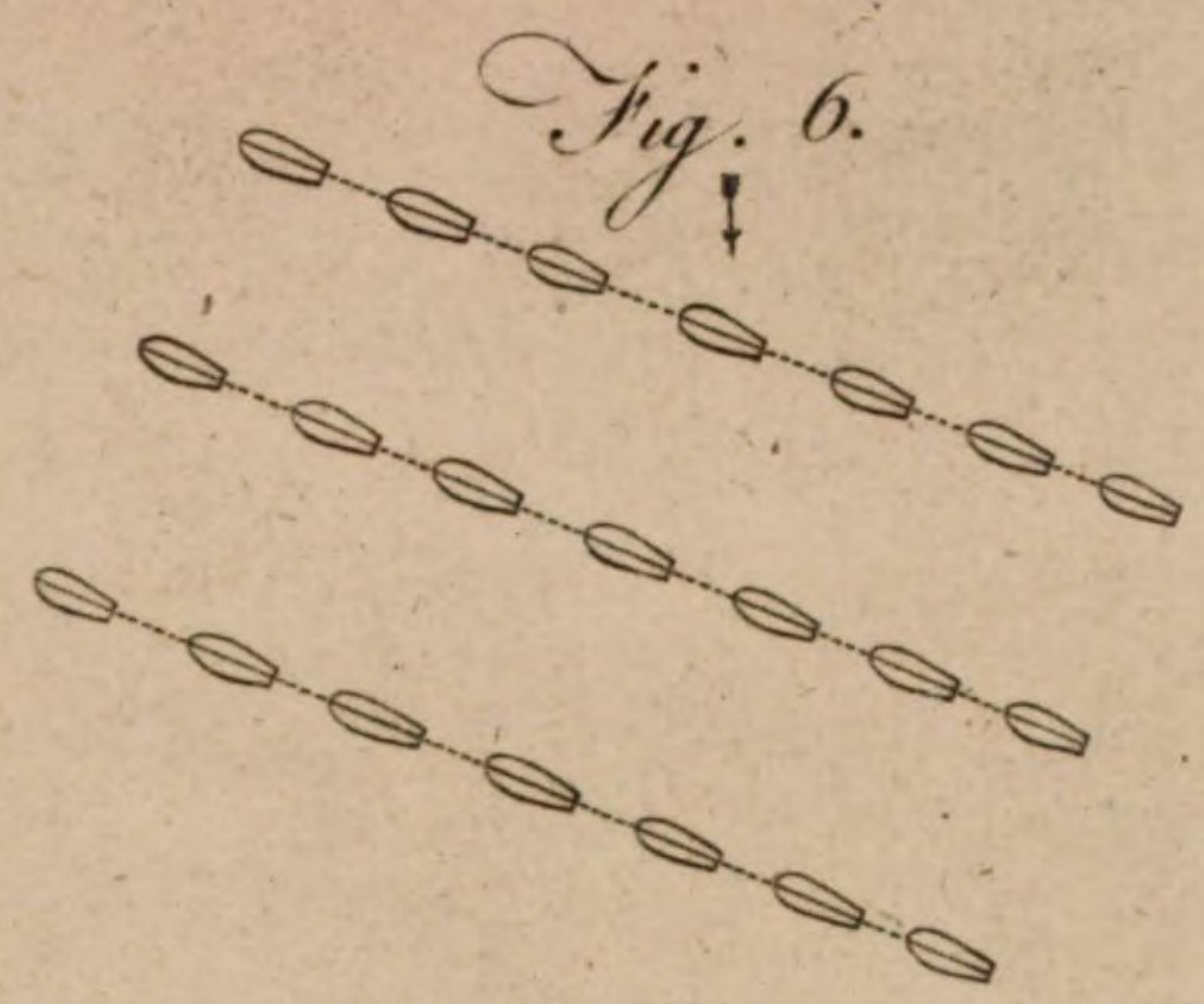
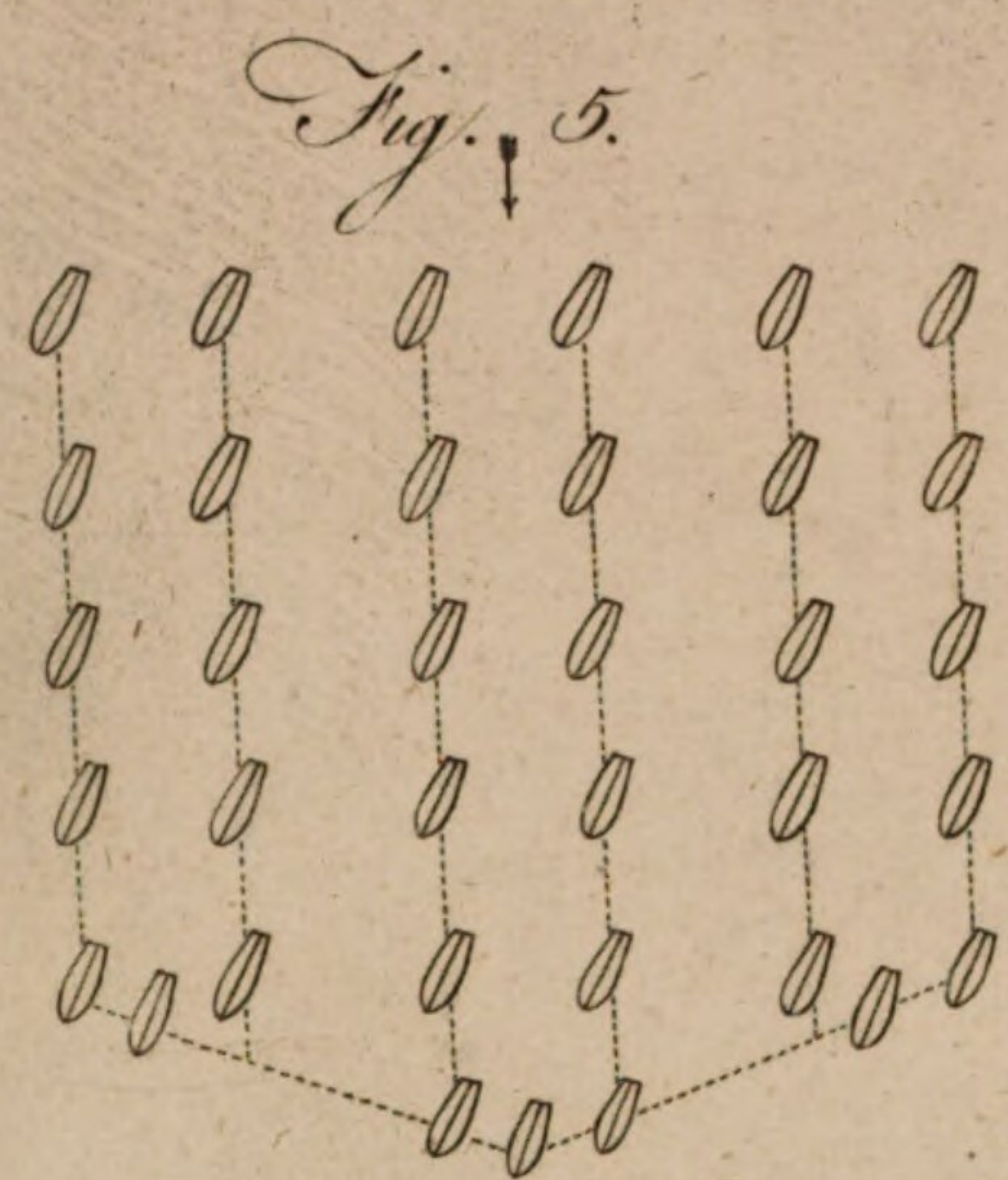
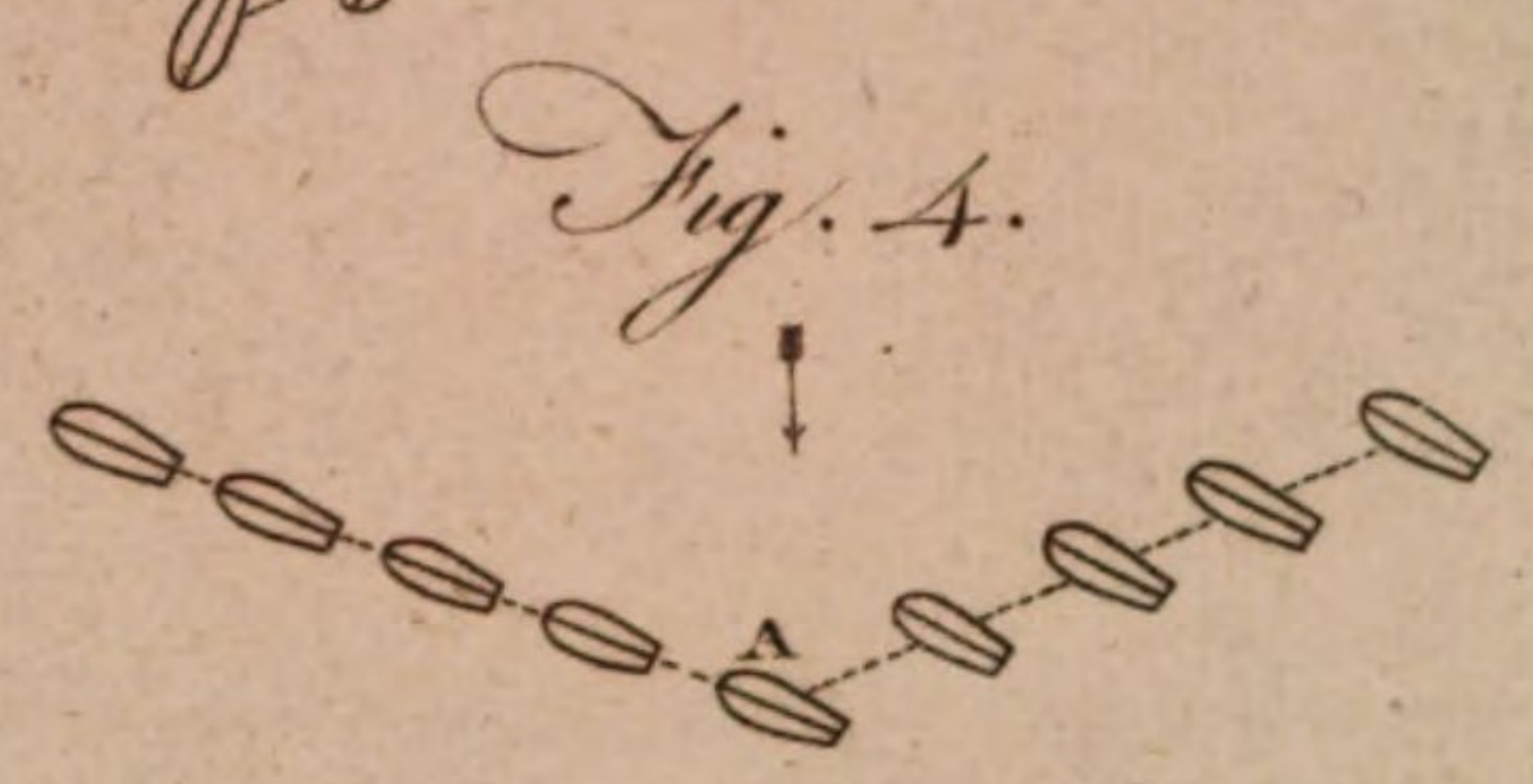
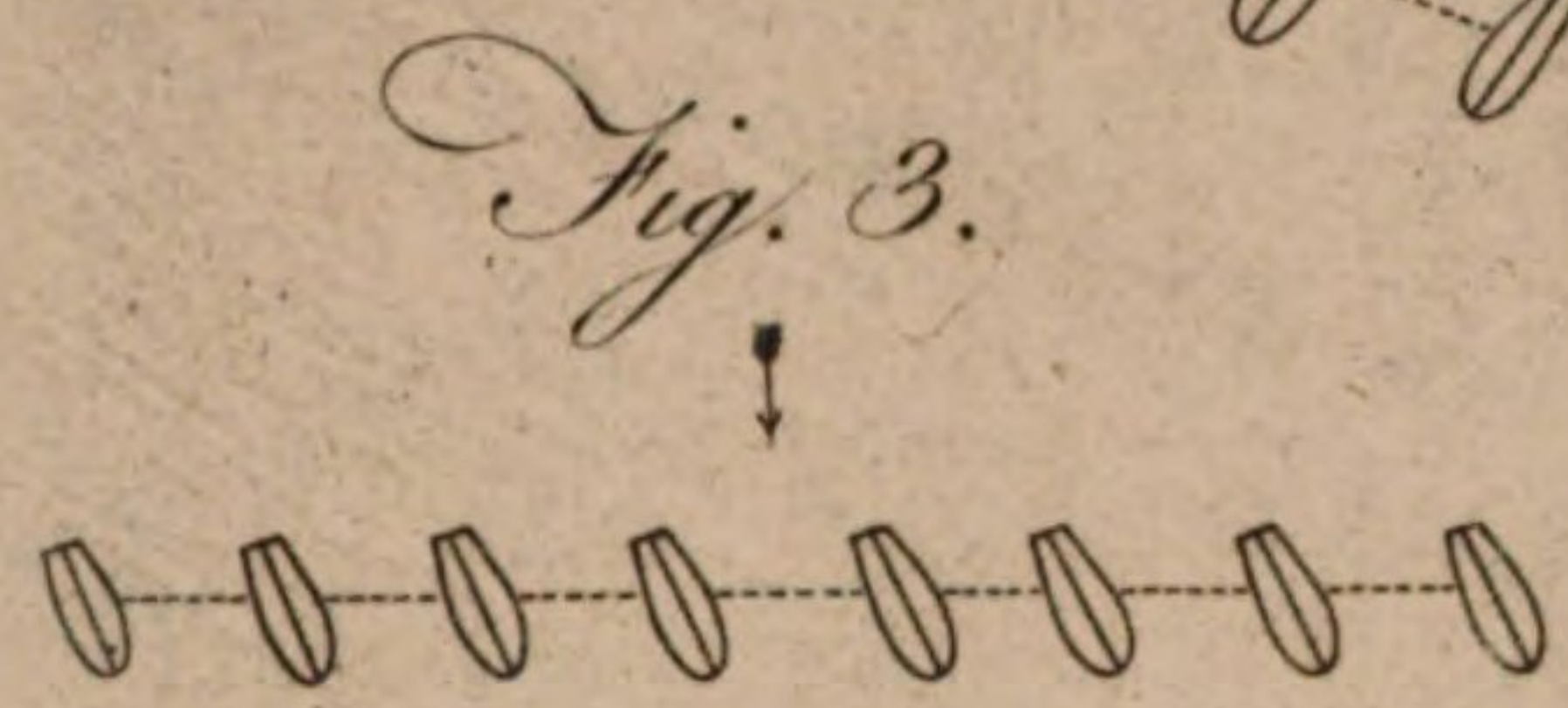
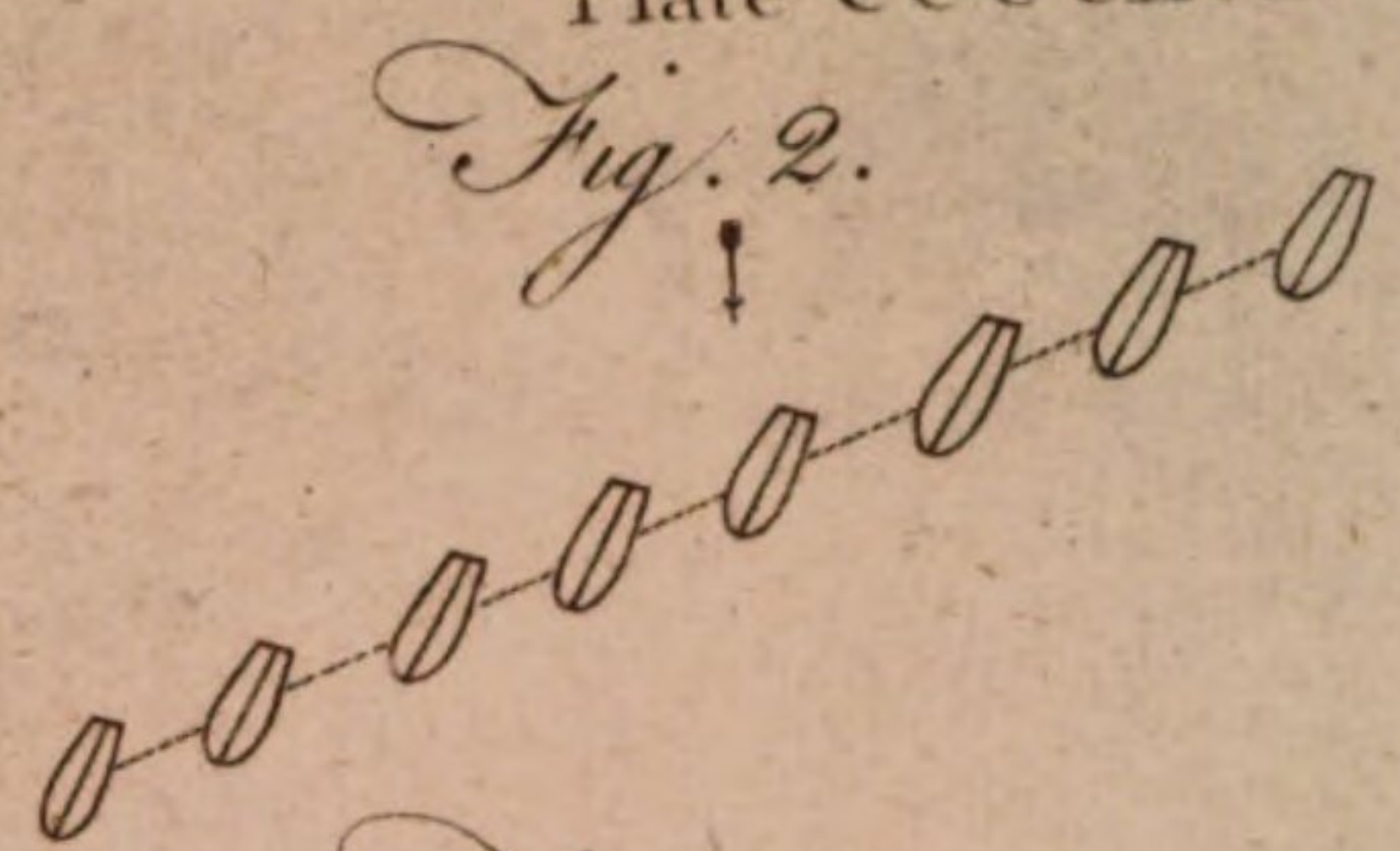
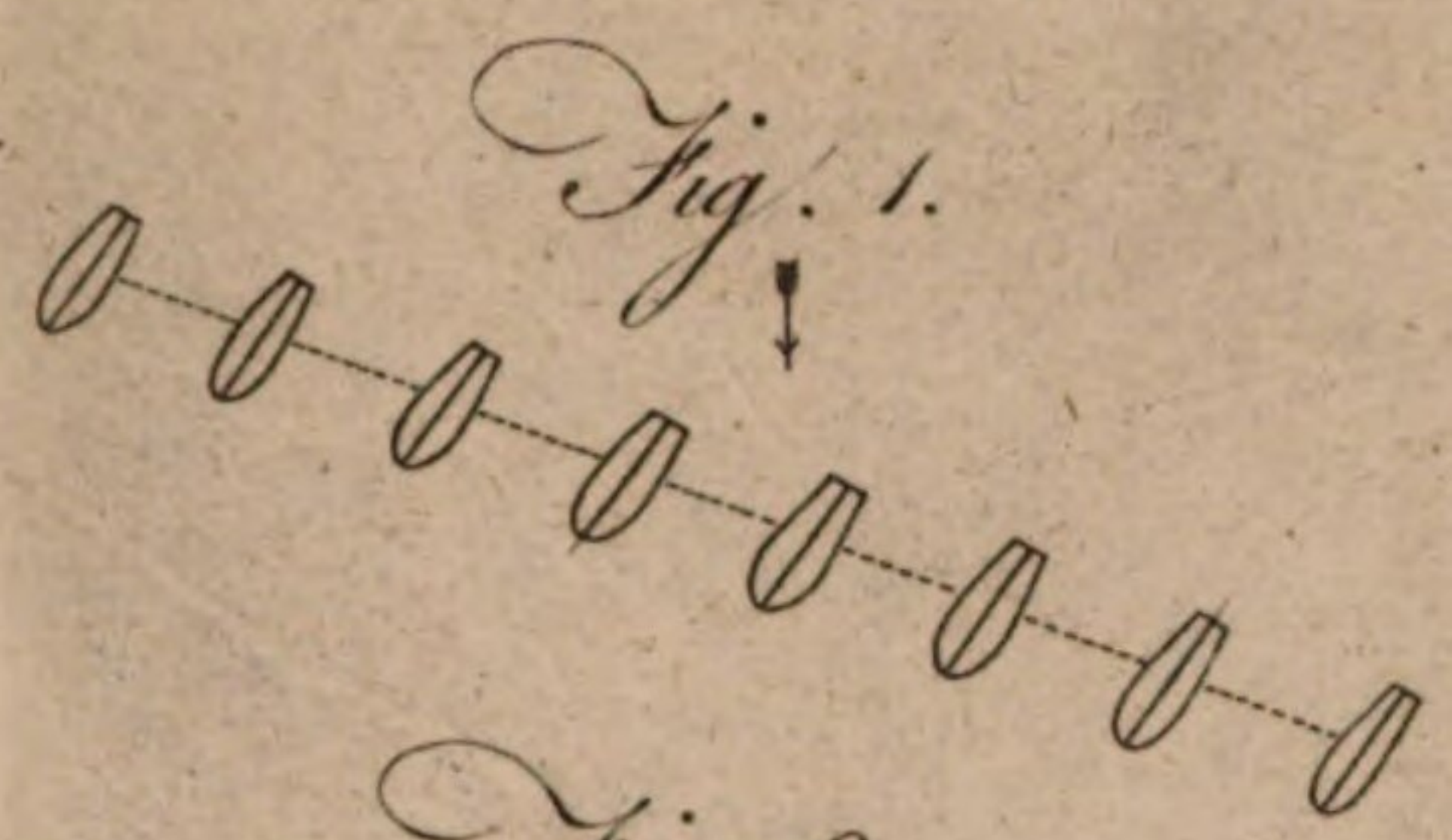


Fig. 12.

Fig. 11.

Fig. 13.

Fig. 14.

Fig. 16.

Fig. 15.

Fig. 17.

Fig. 18.

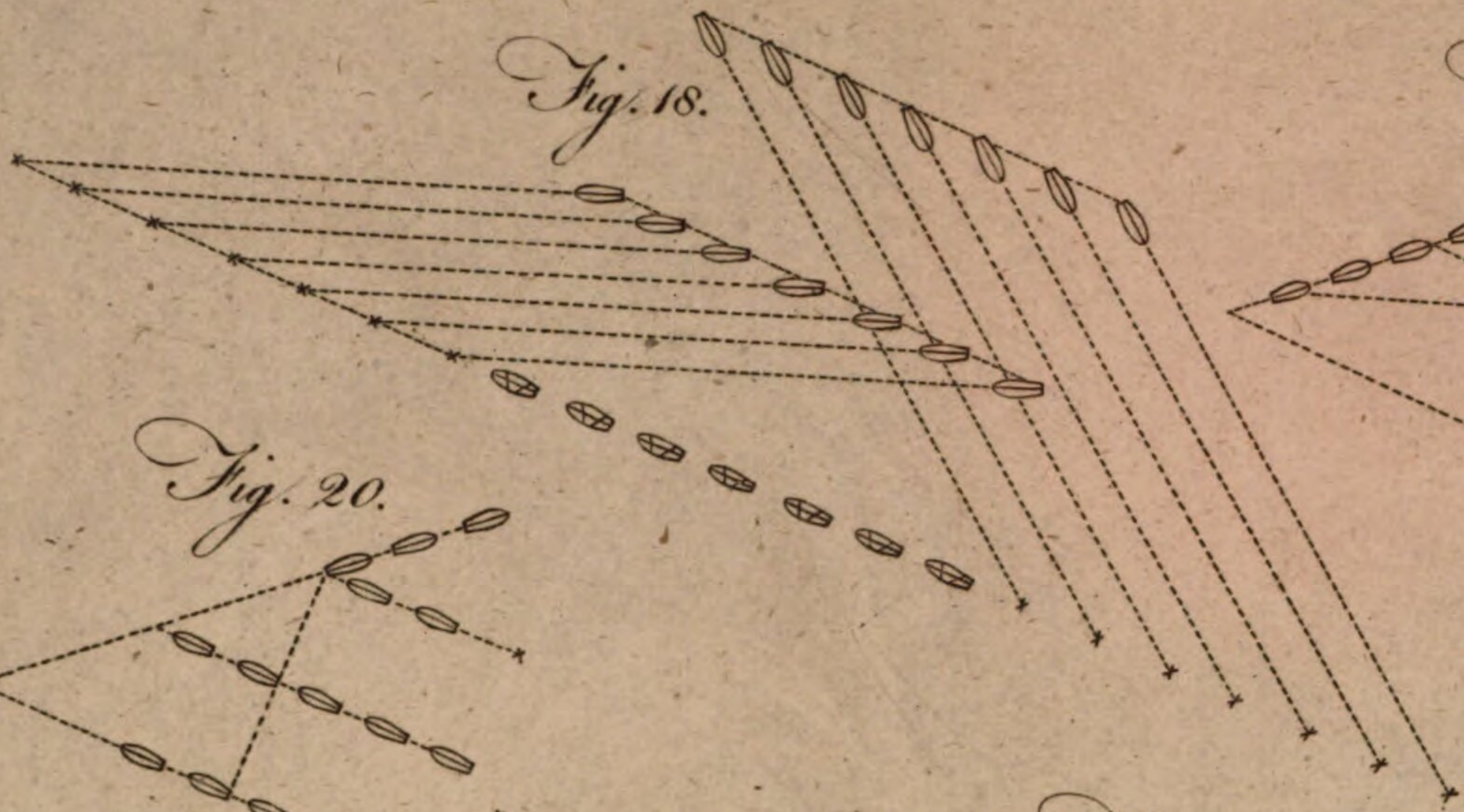


Fig. 22.

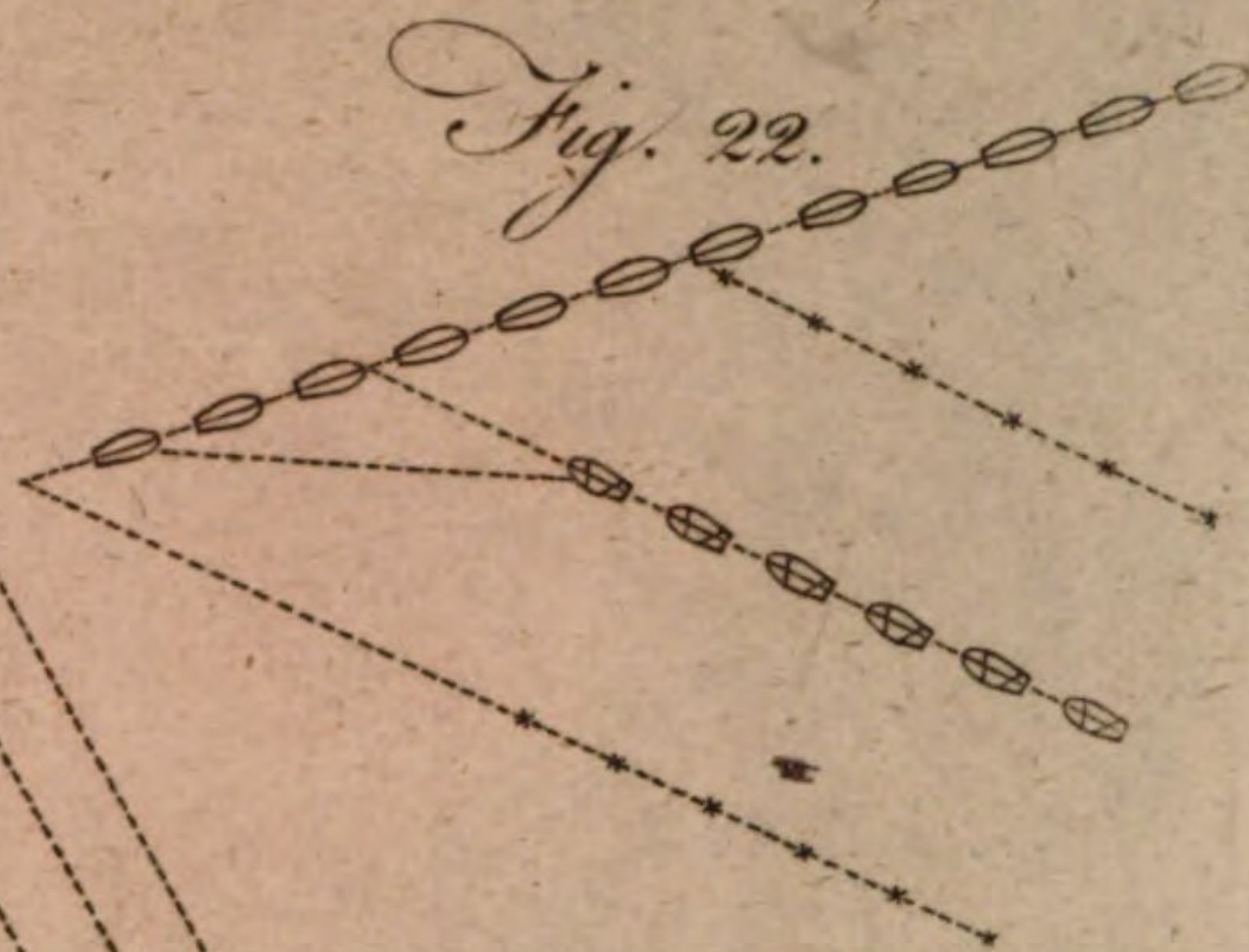


Fig. 20.

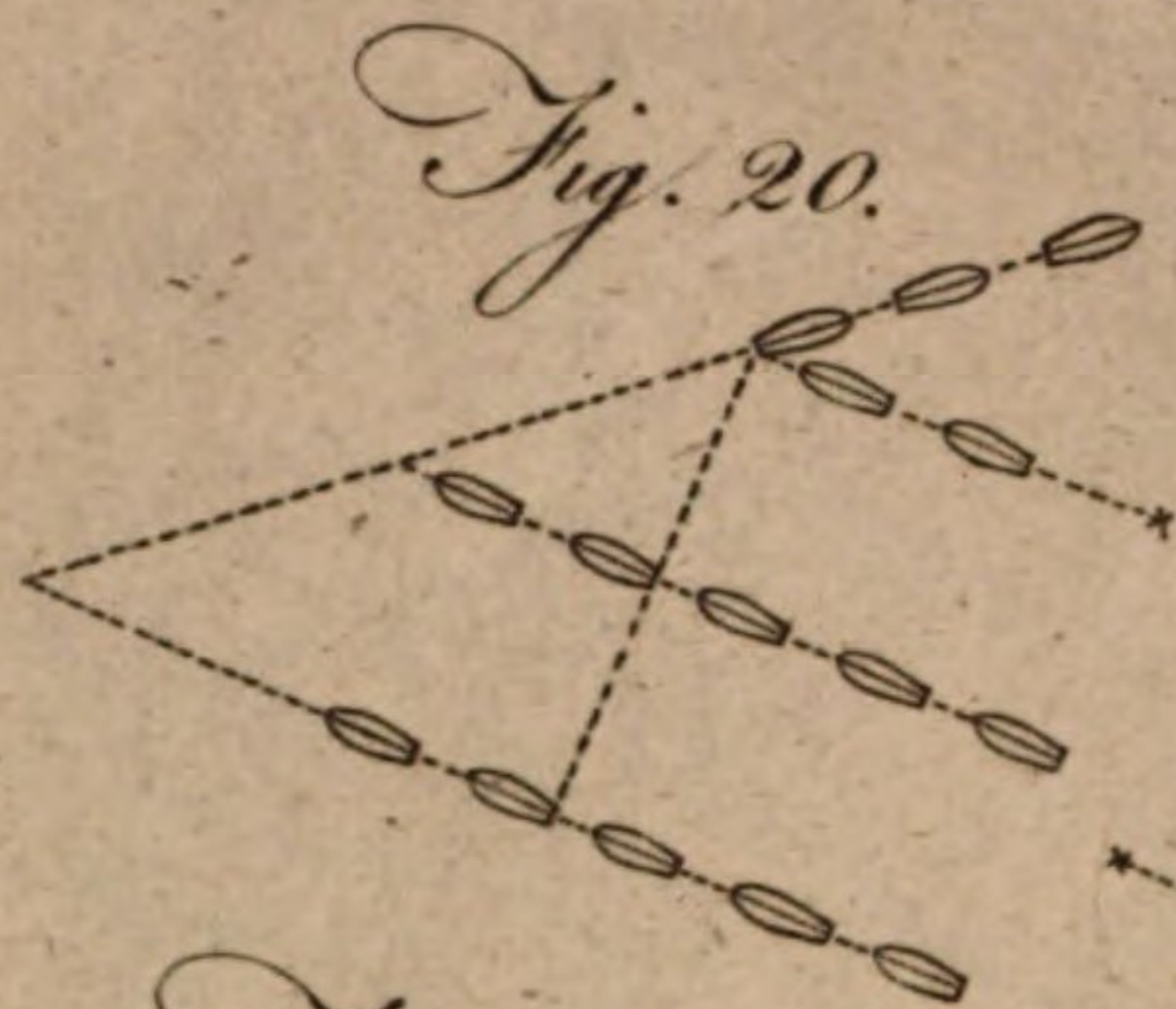


Fig. 19.

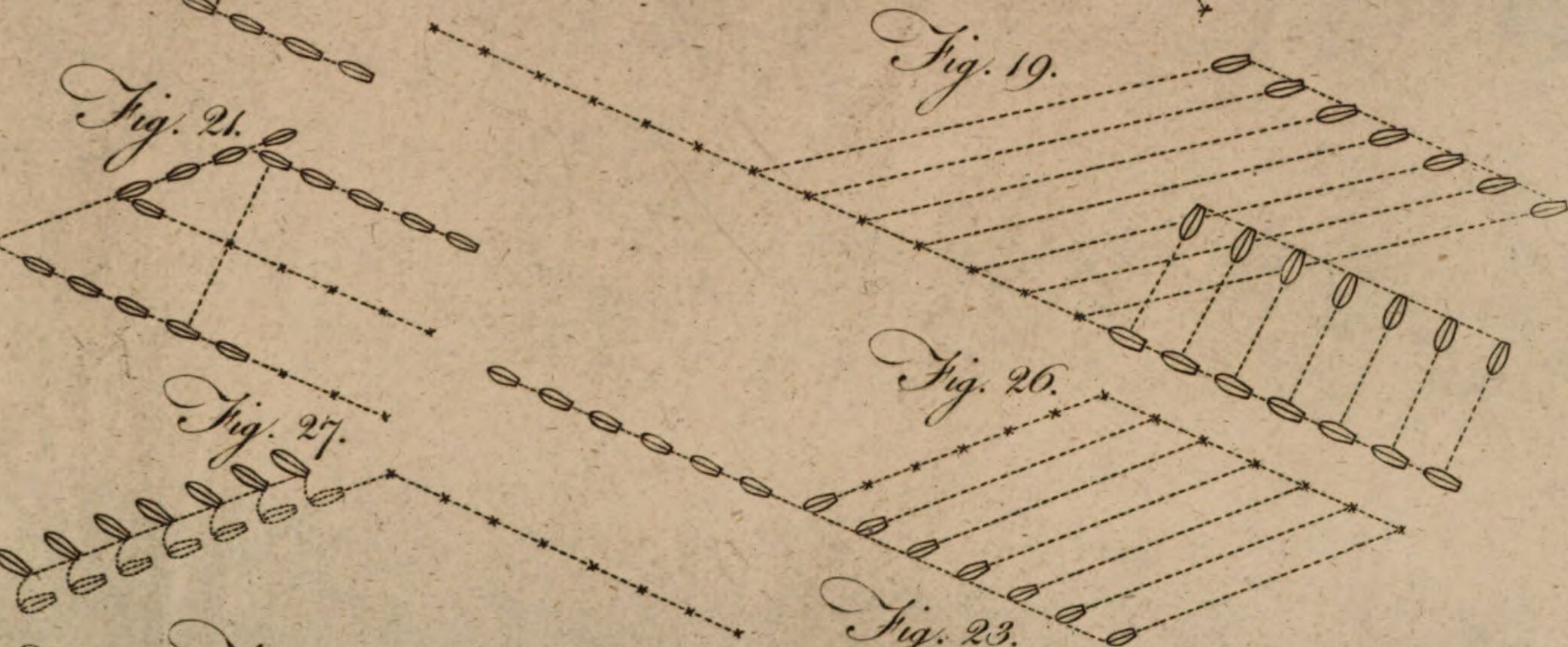


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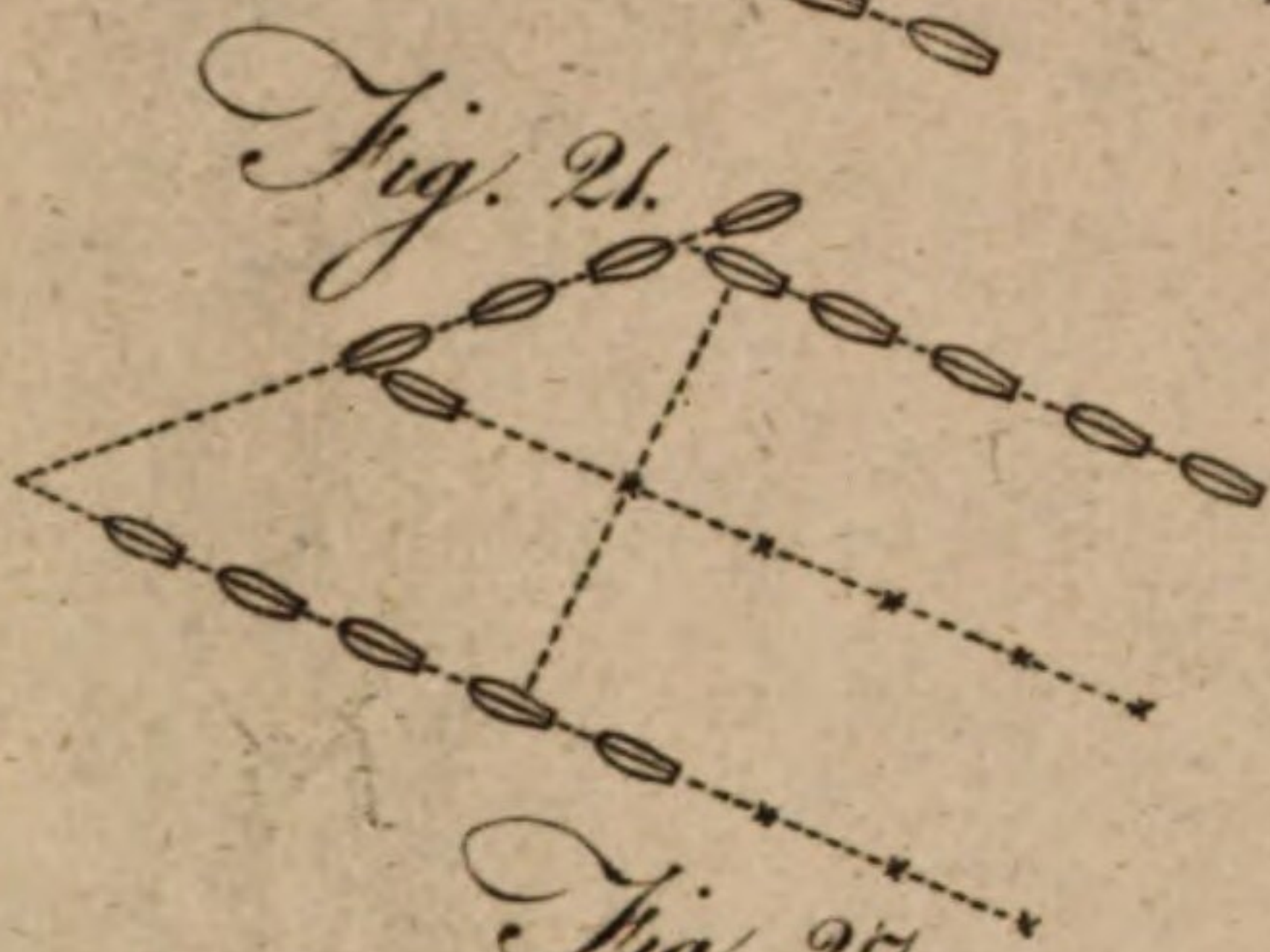


Fig. 26.



Fig. 27.

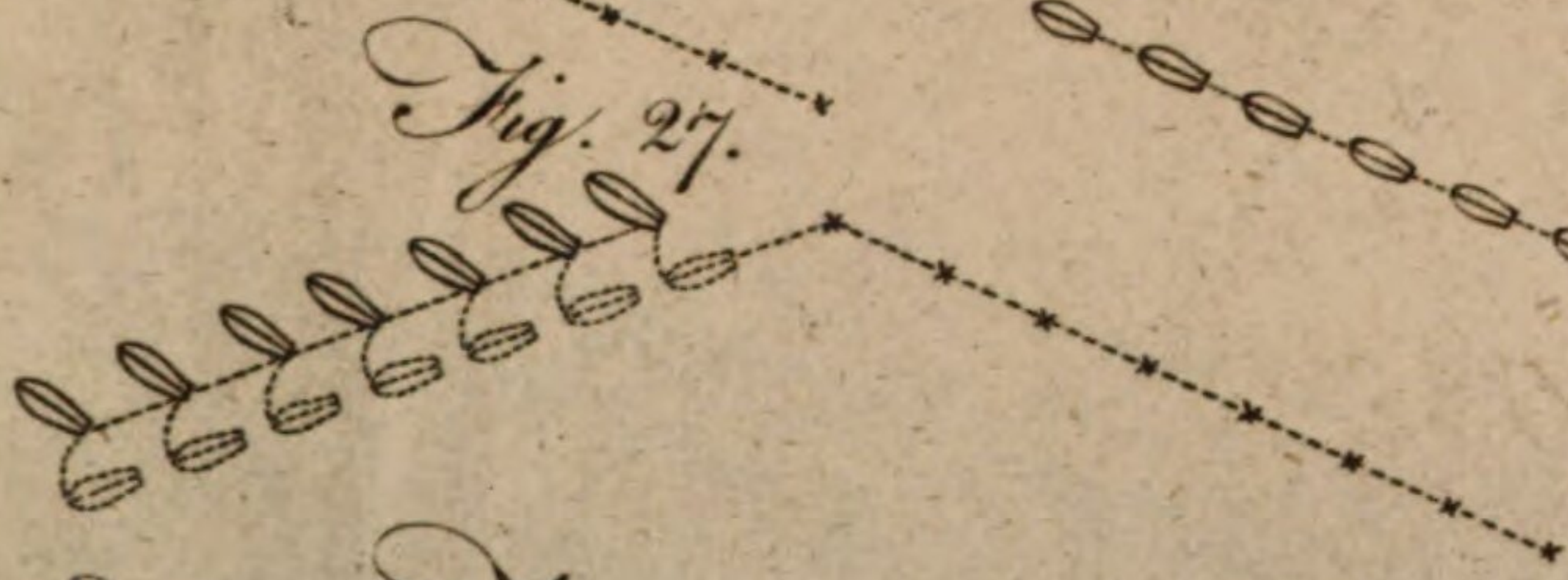


Fig. 23.



Fig. 28.

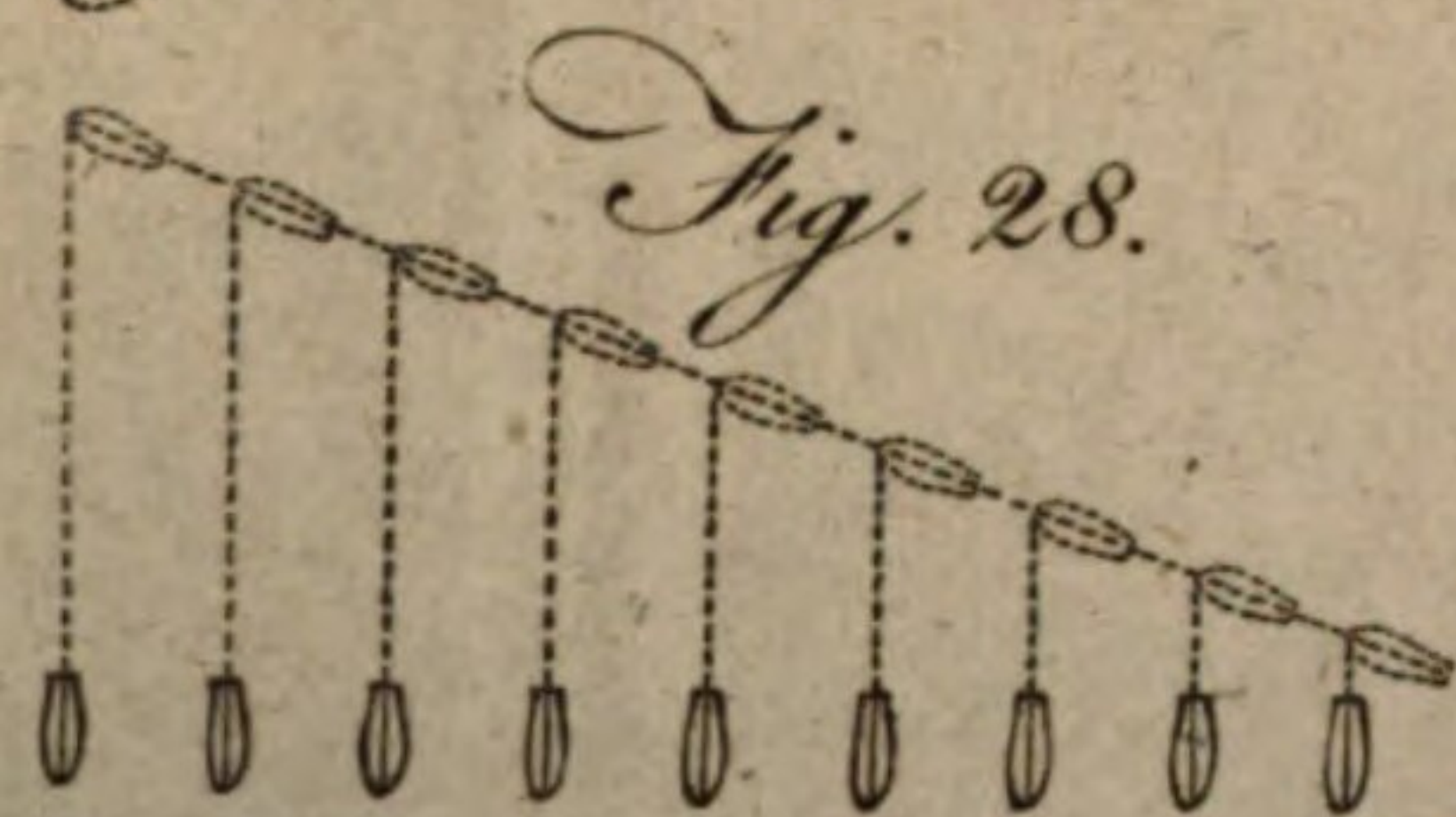


Fig. 24.



Fig. 25.

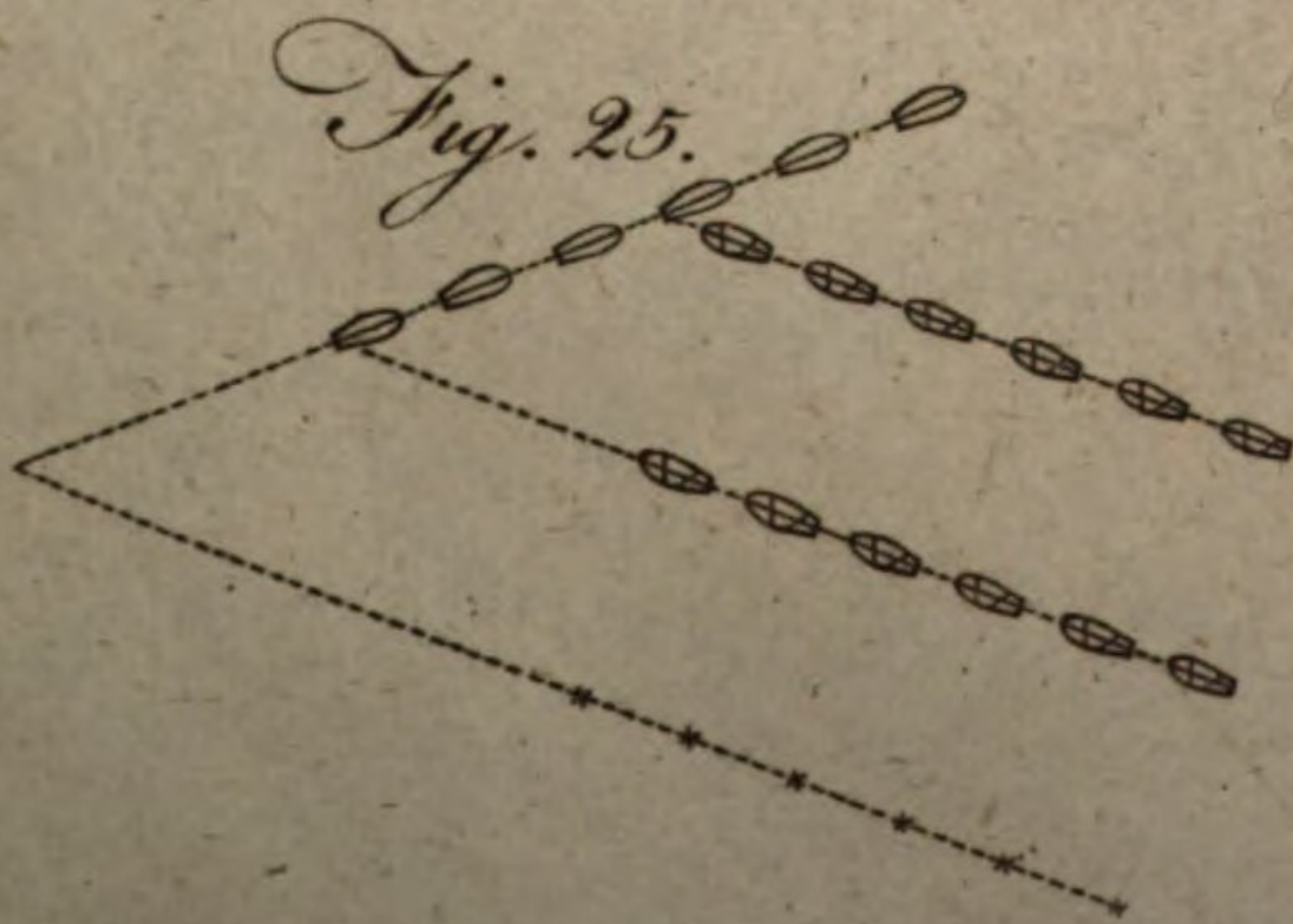


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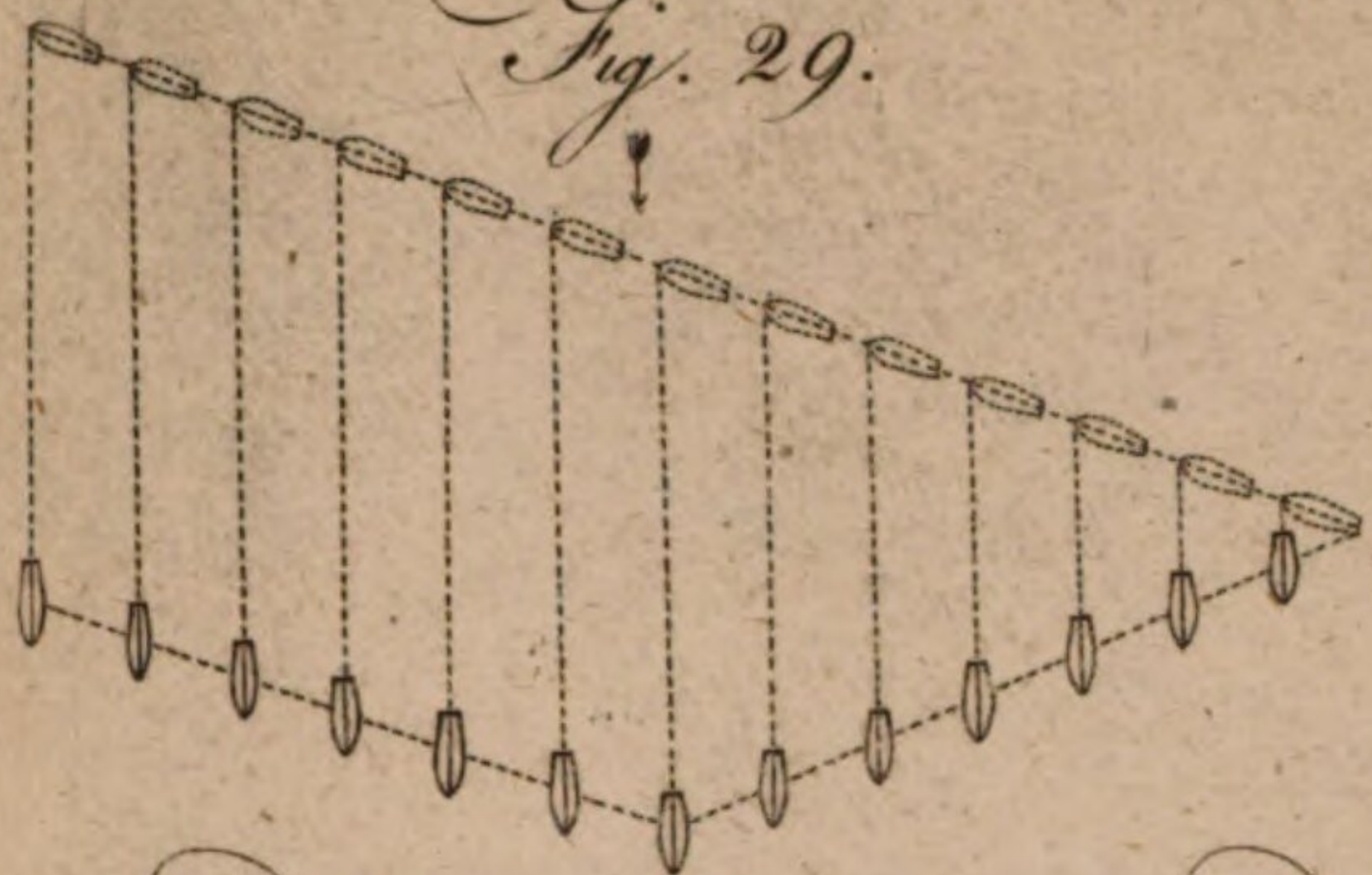


Fig. 31.

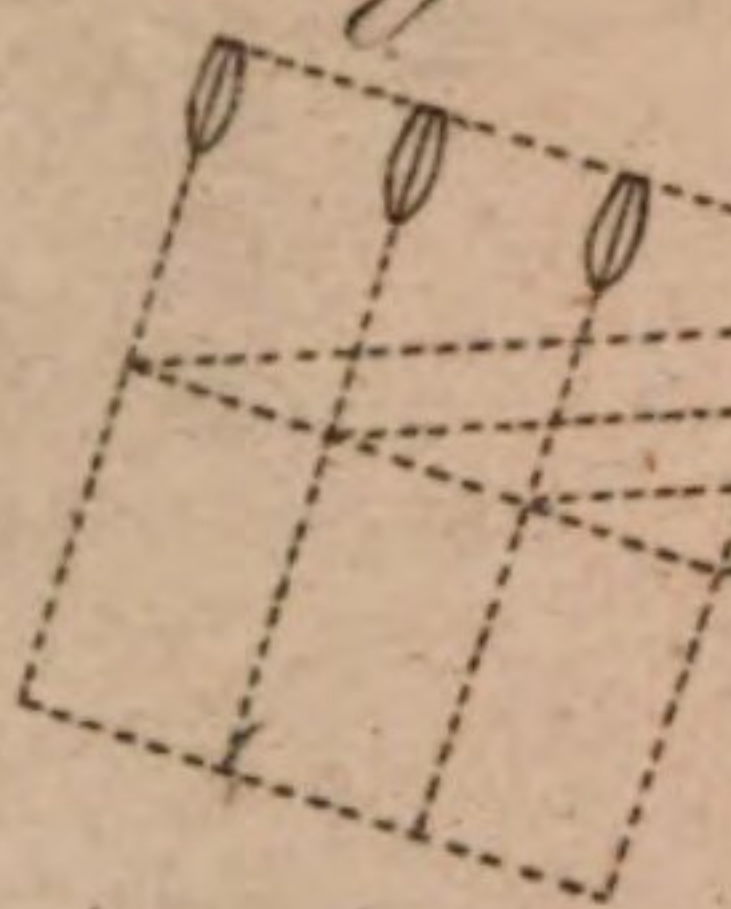


Fig. 30.

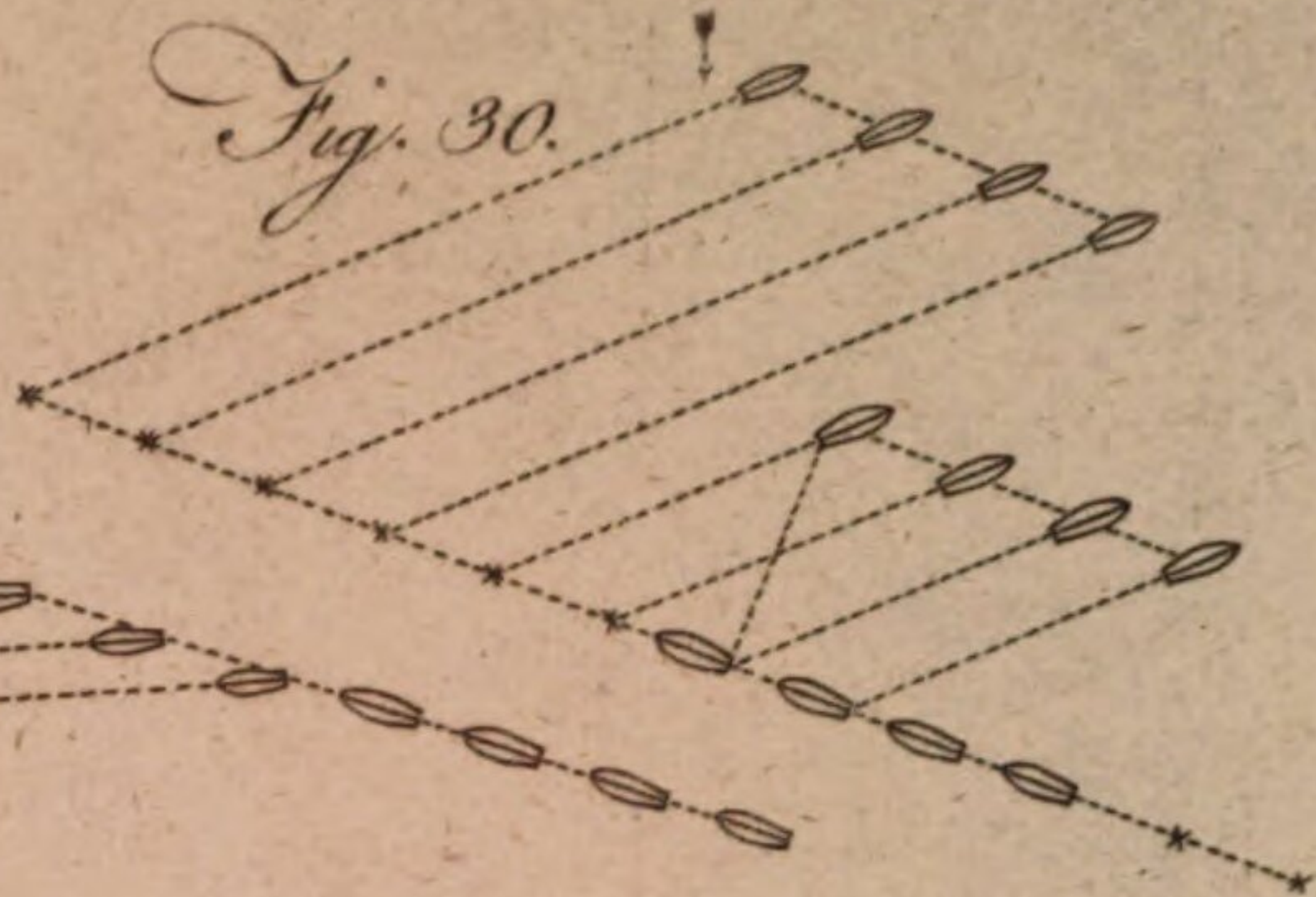


Fig. 32.

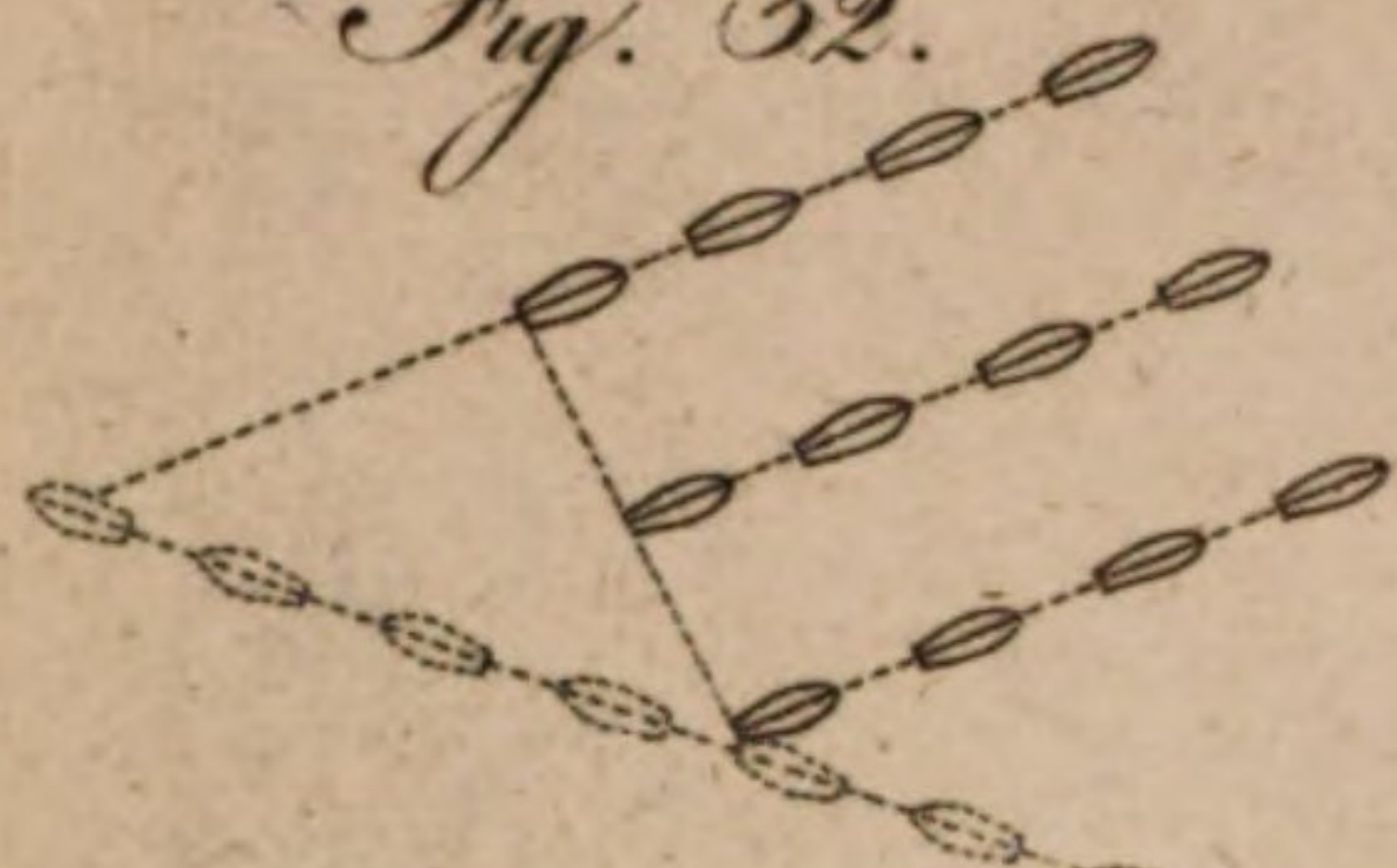


Fig. 33.

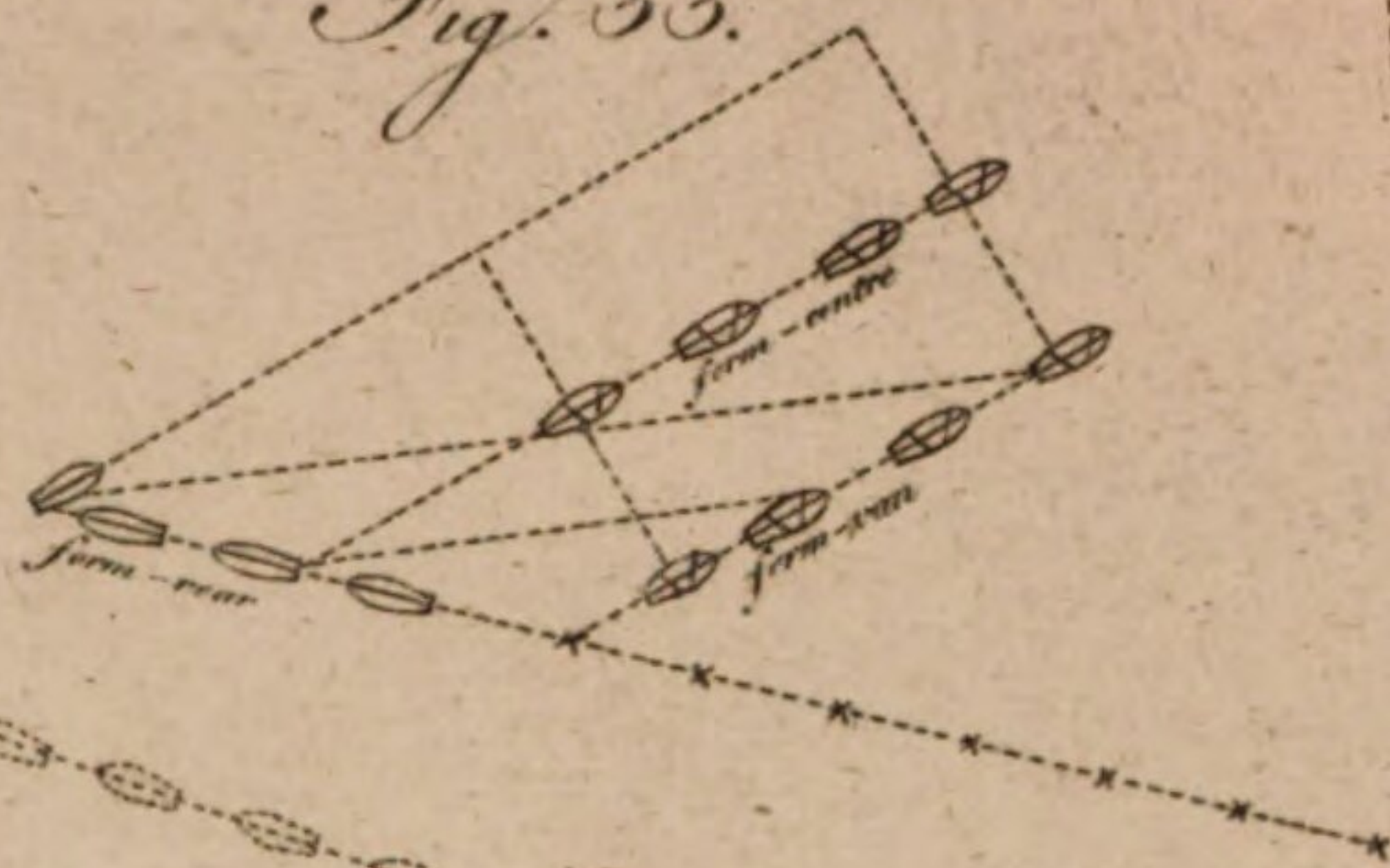


Fig. 34.

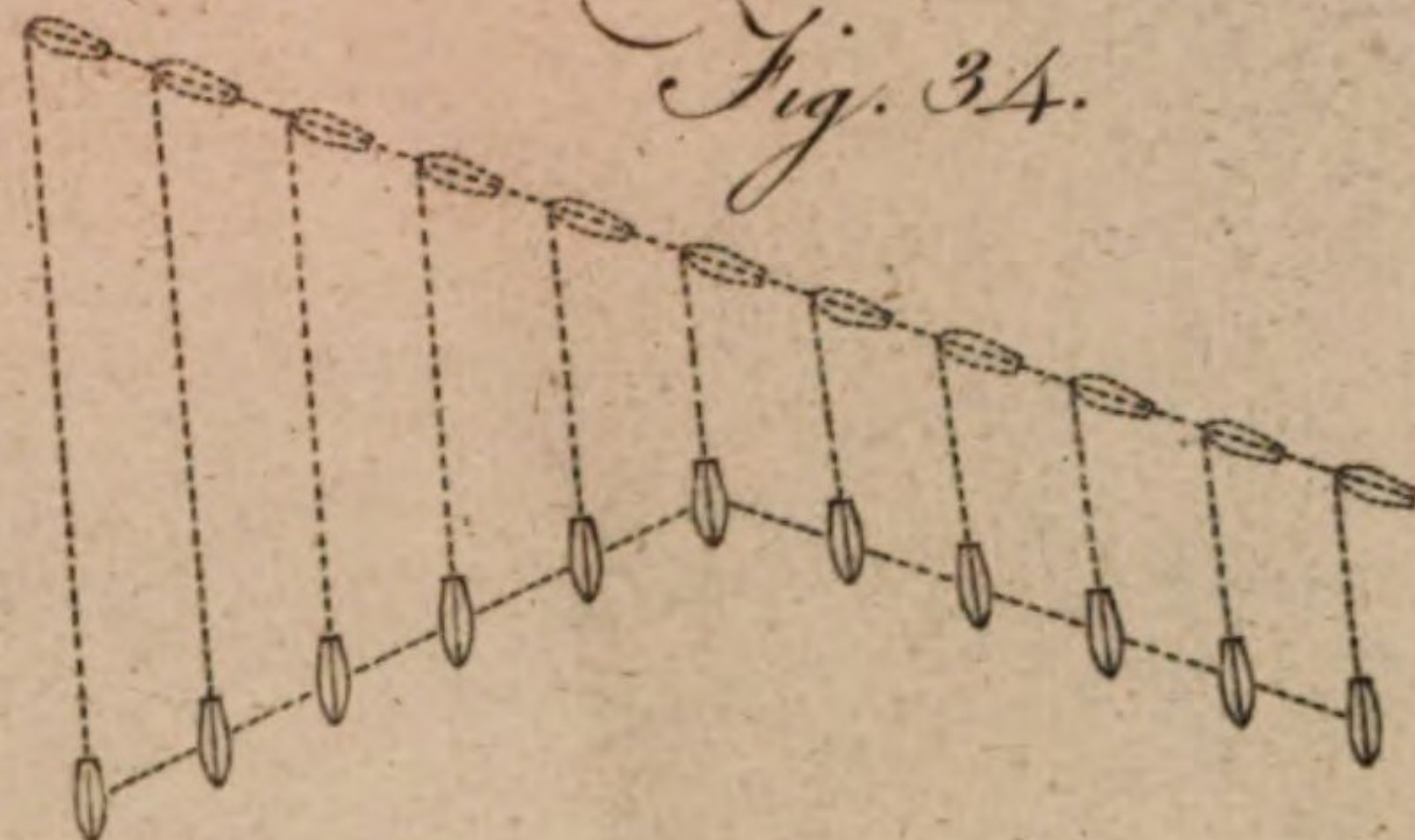


Fig. 35.



Fig. 36.

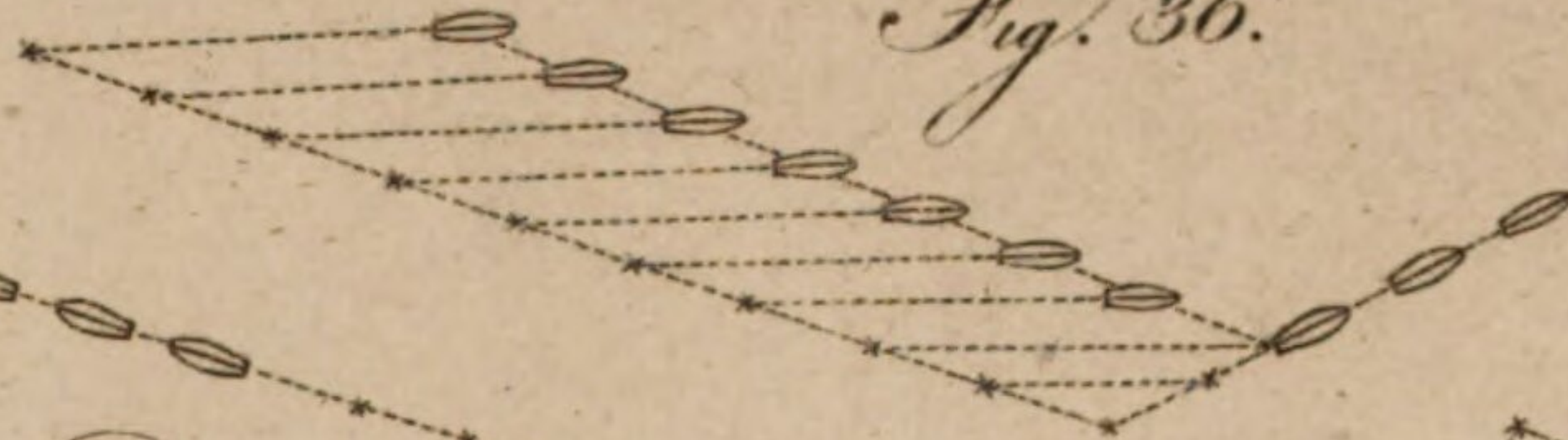


Fig. 37.



Fig. 39.

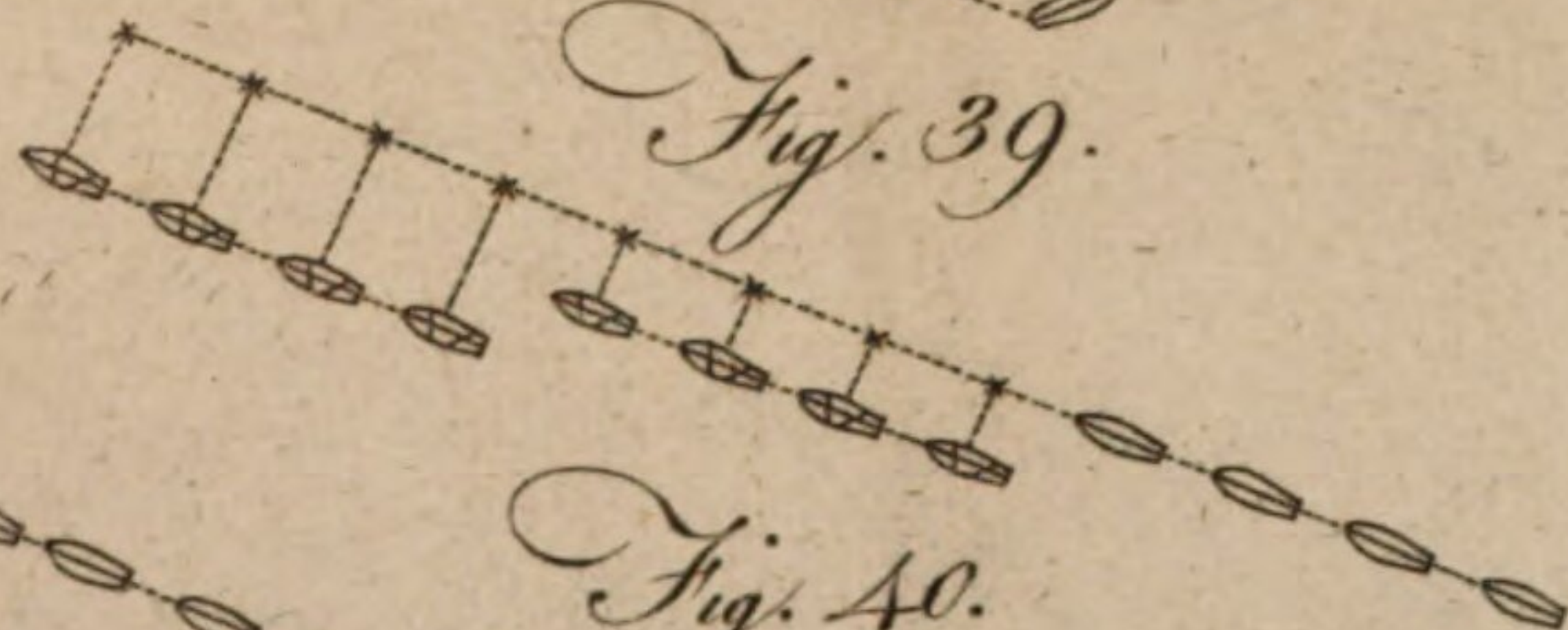
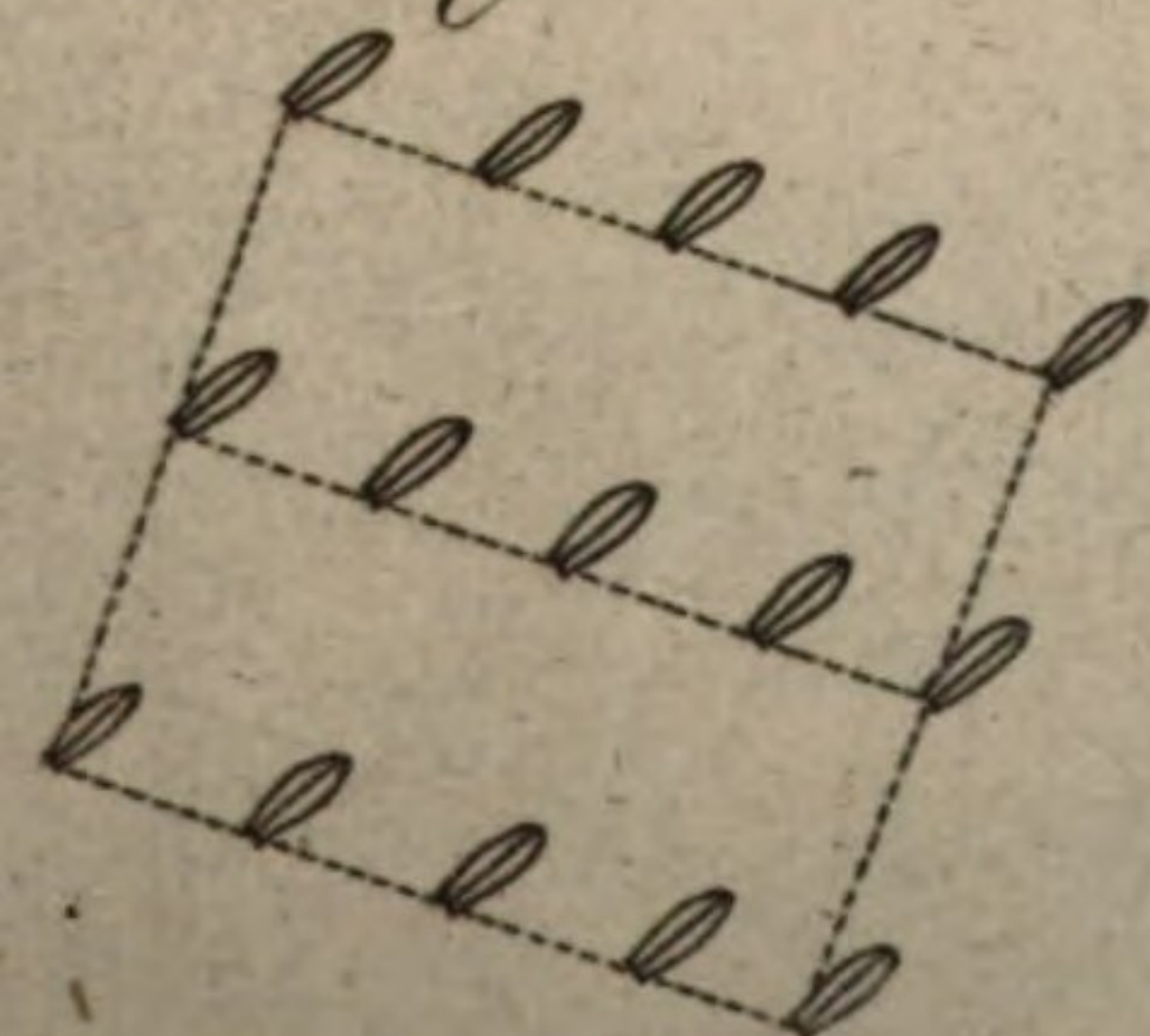


Fig. 40.



Fig. 42.



Ad Bell Pin. Mal. sculptor fecit.

Fig. 38.



Fig. 41.

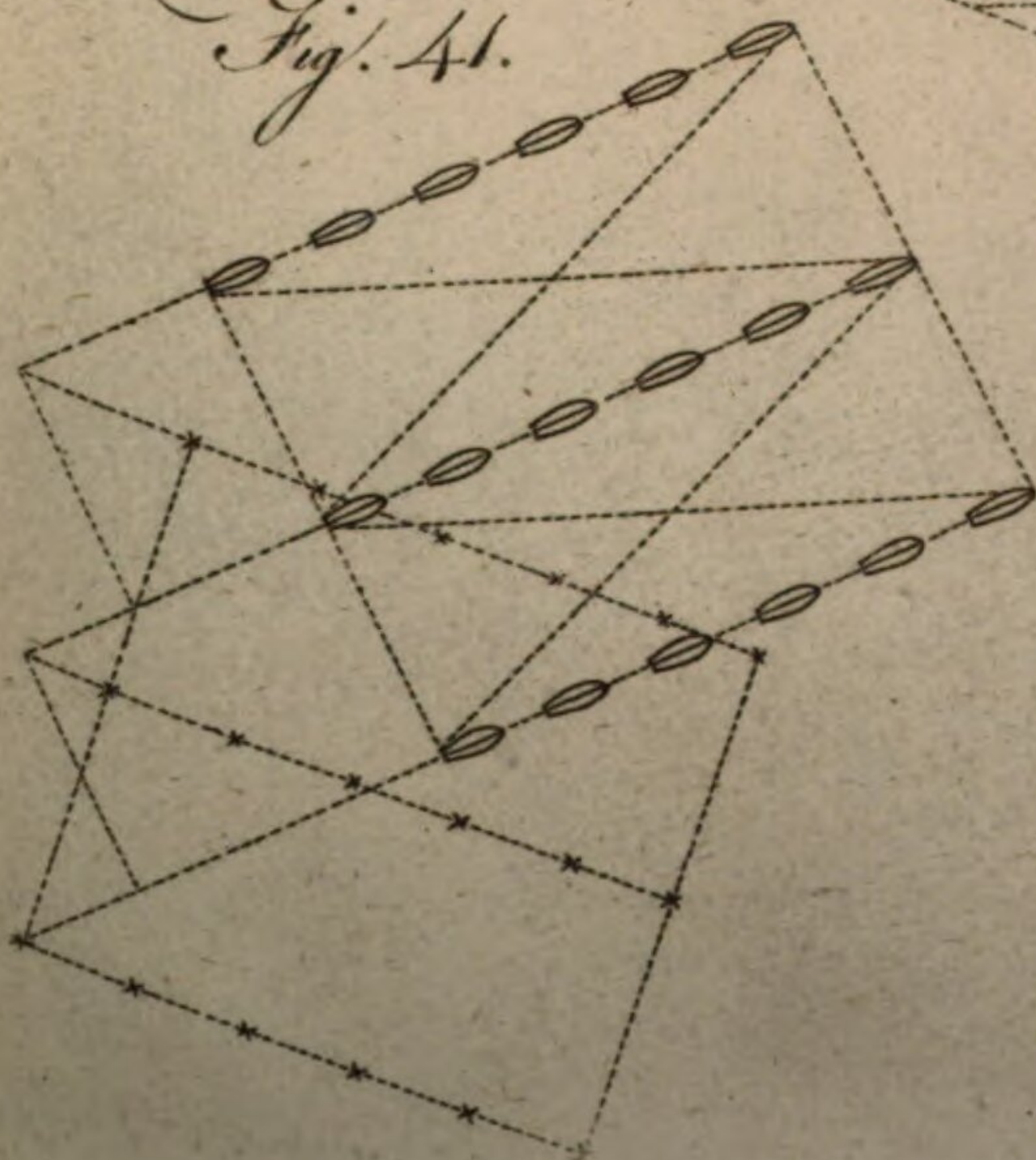


Fig. 43.

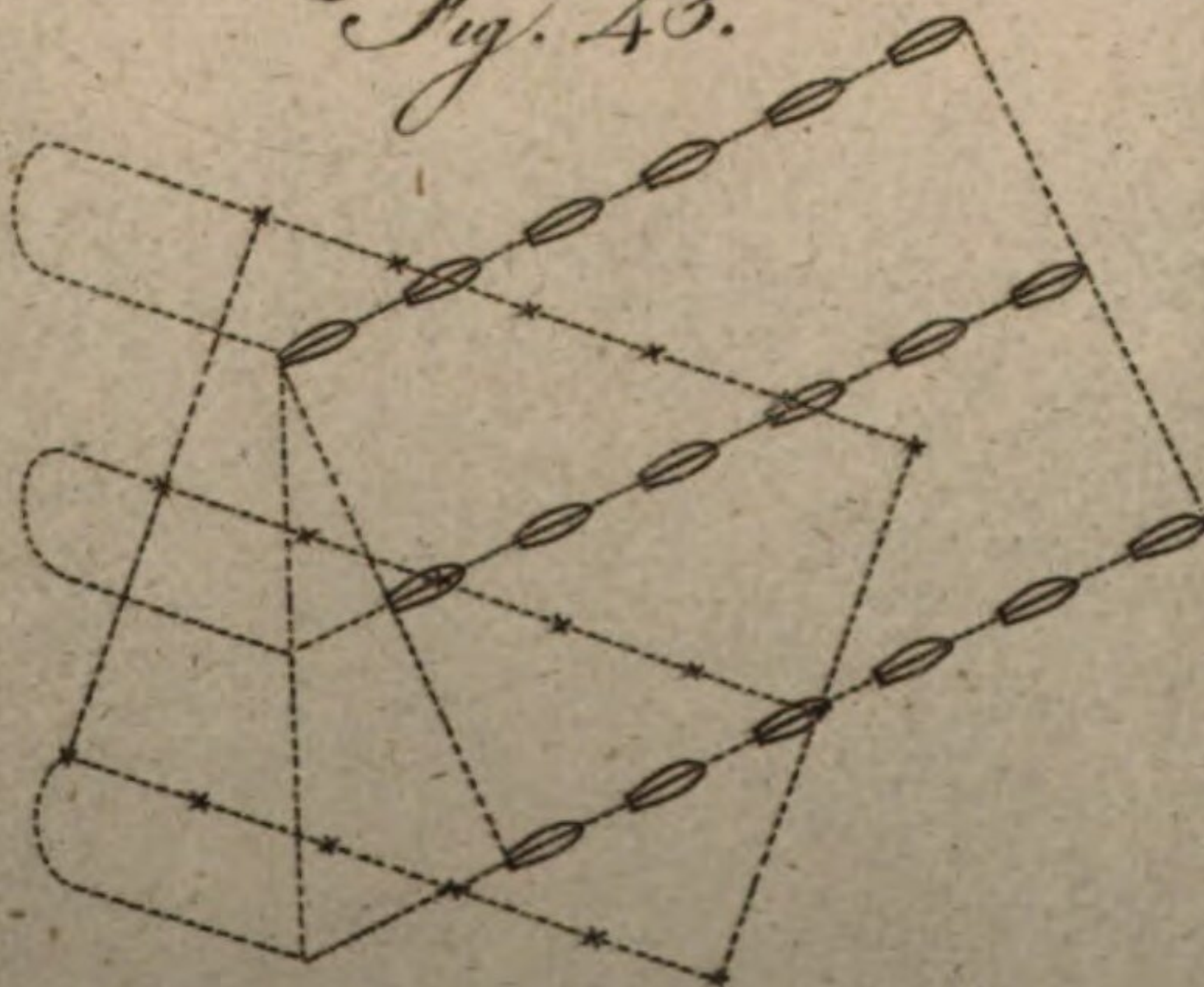


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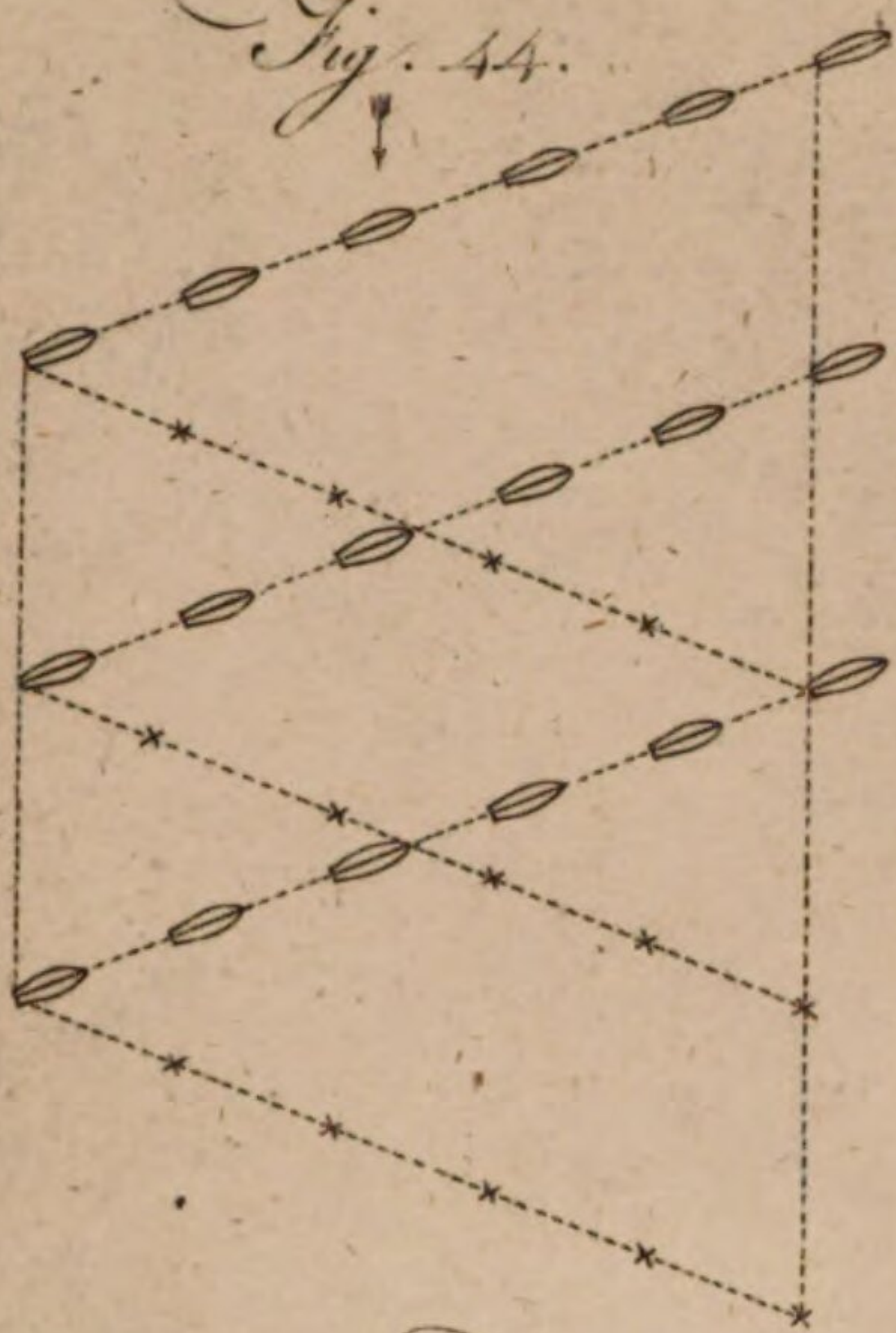


Fig. 45.

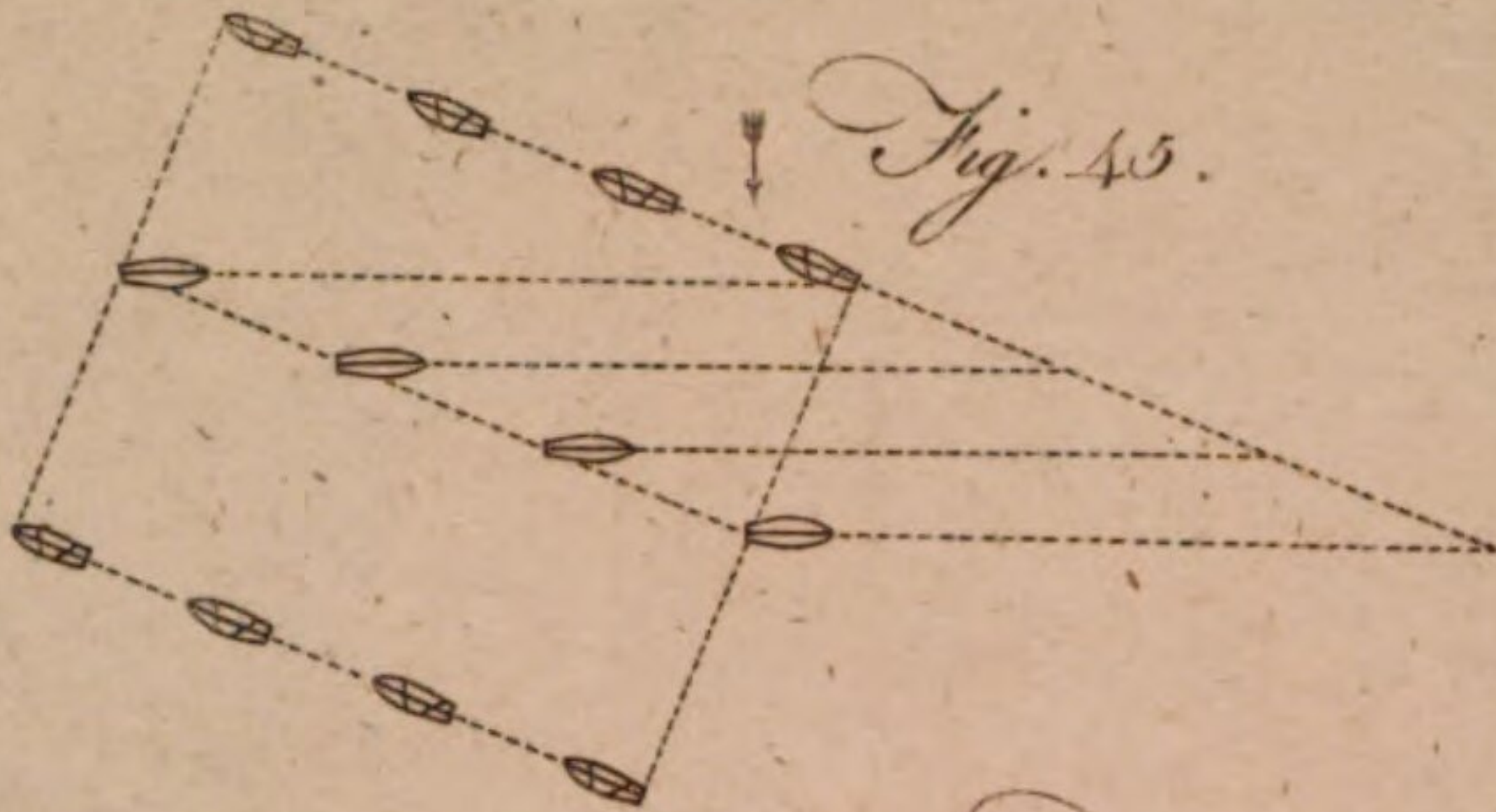


Fig. 49.

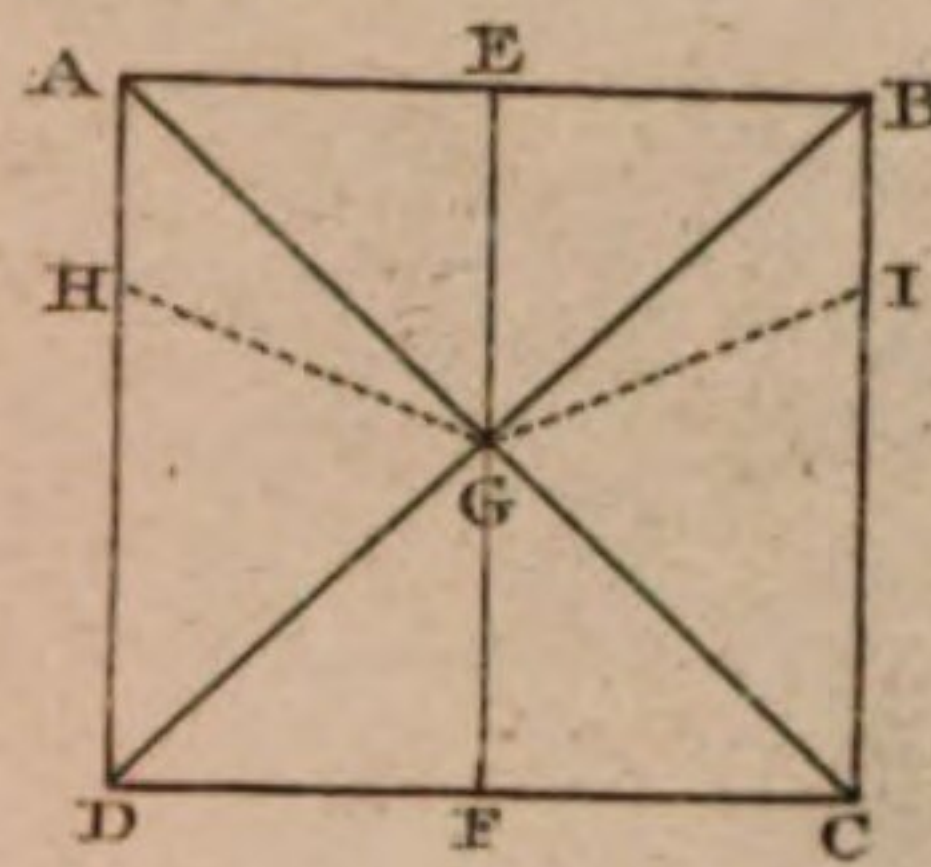


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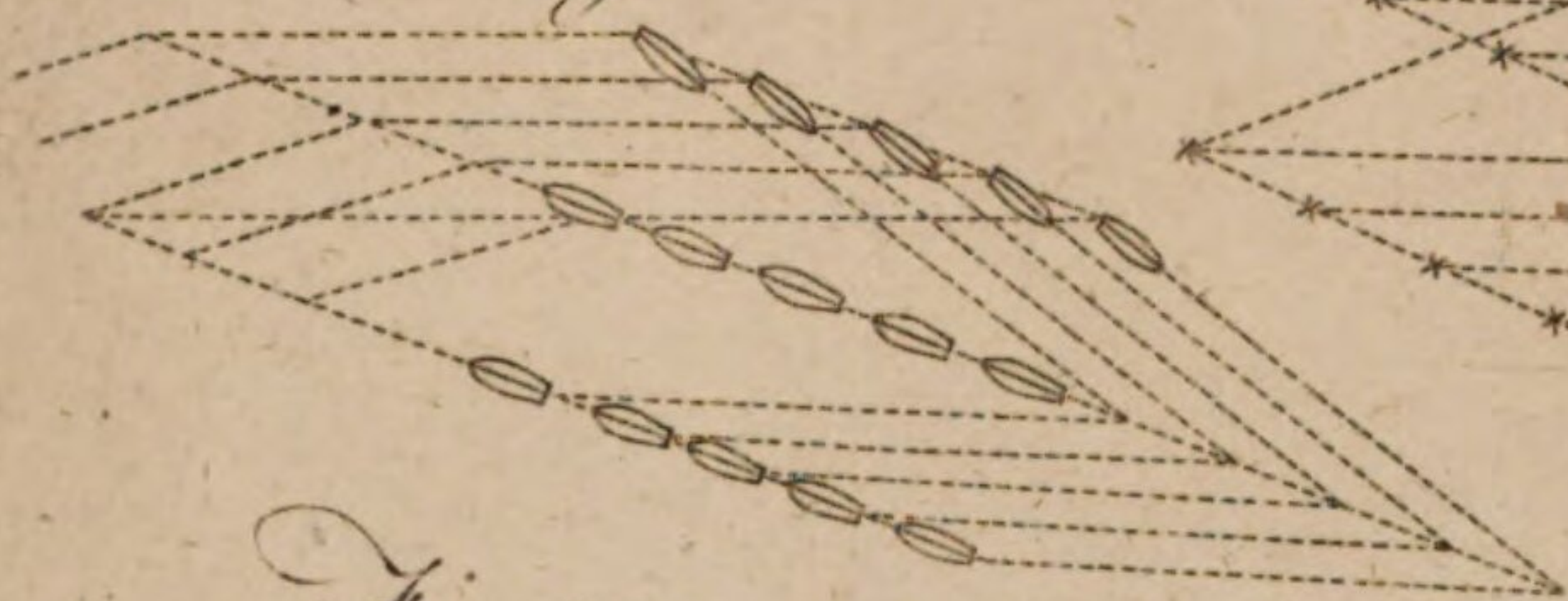


Fig. 48.



Fig. 50.

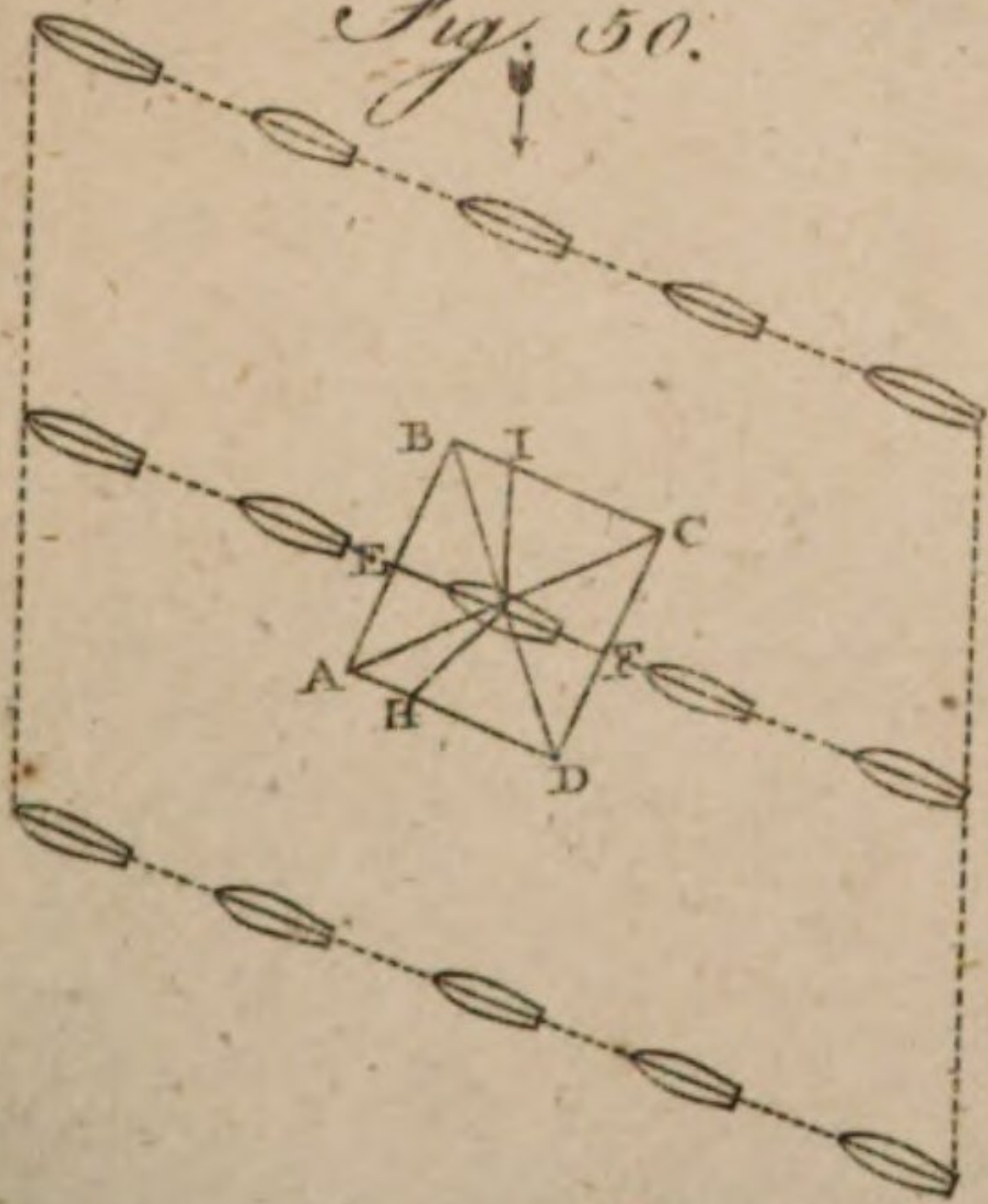


Fig. 53.

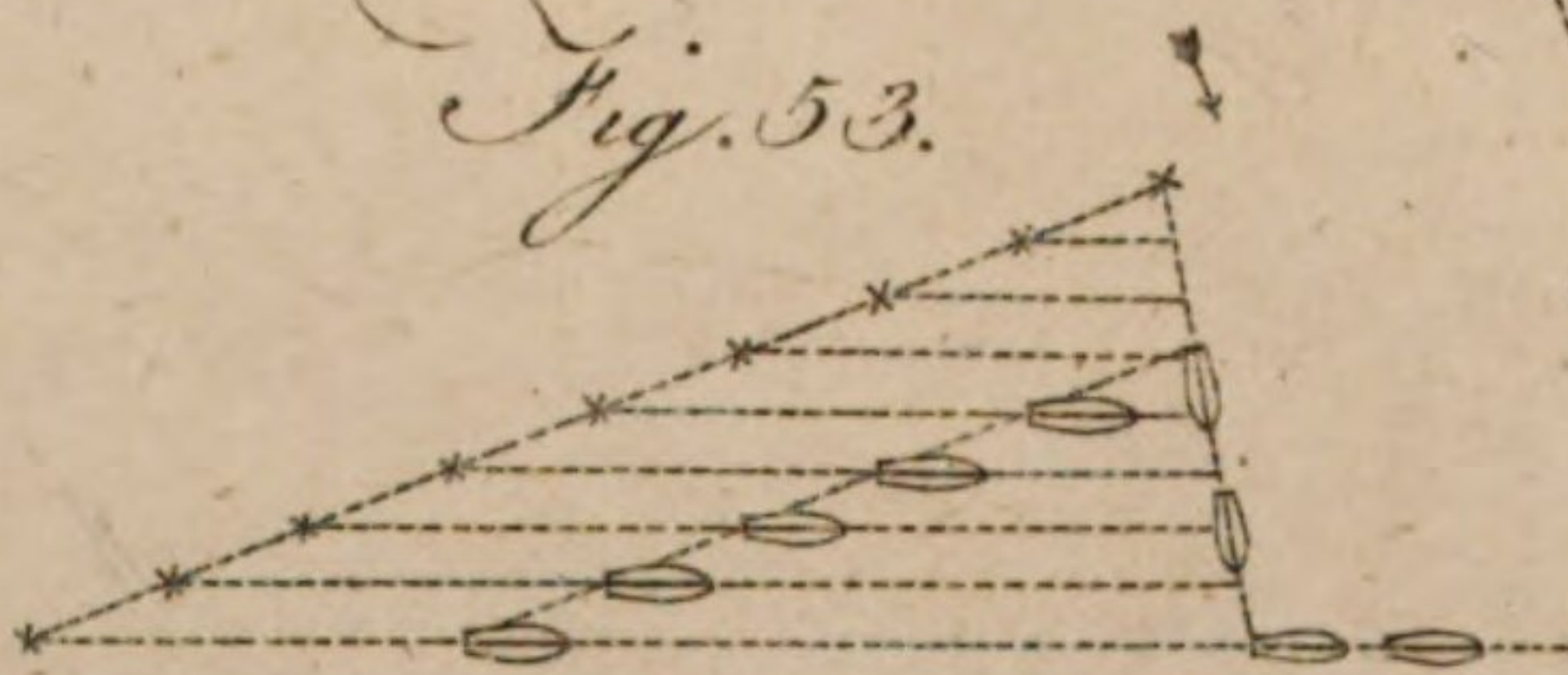


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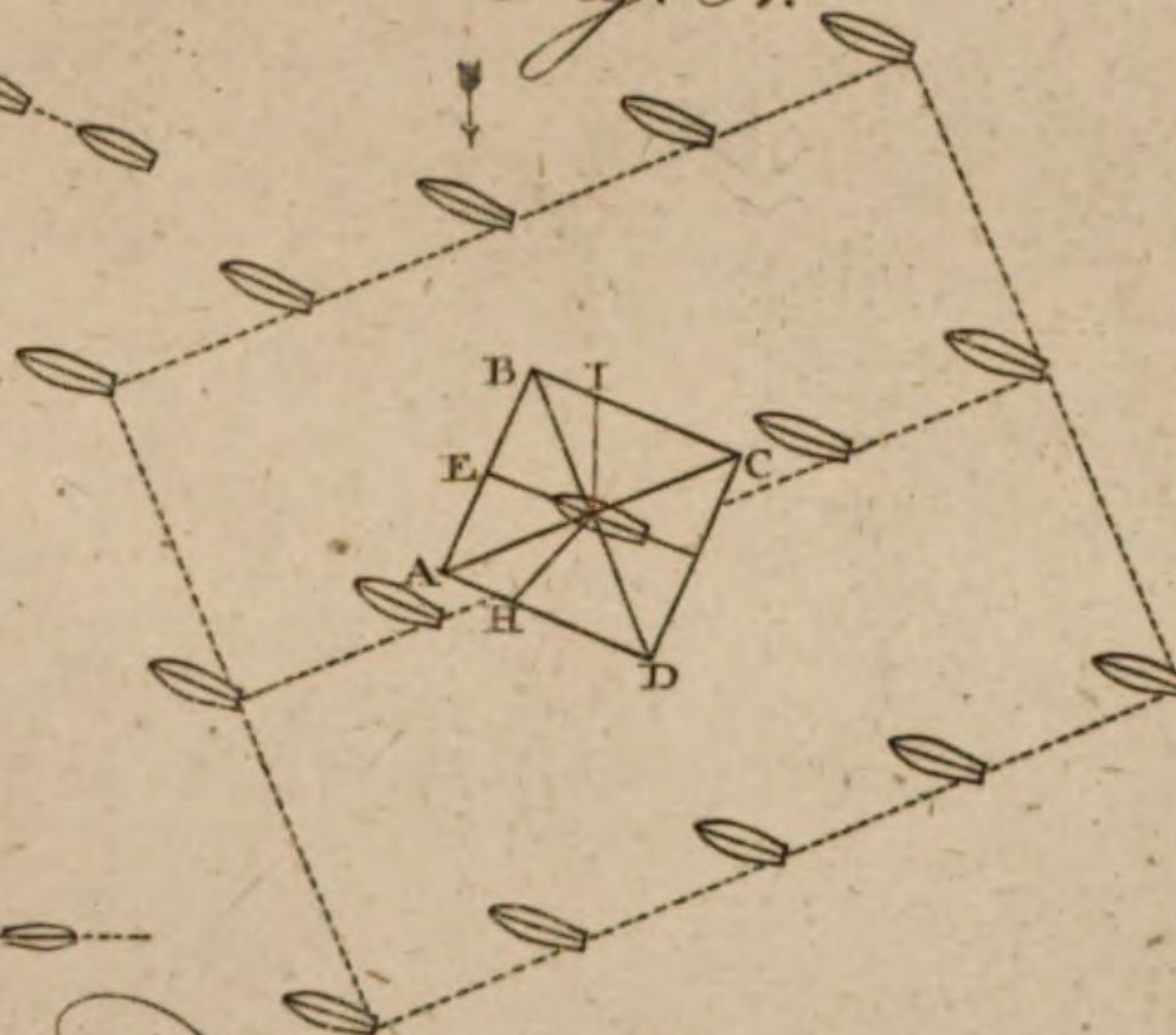


Fig. 55.

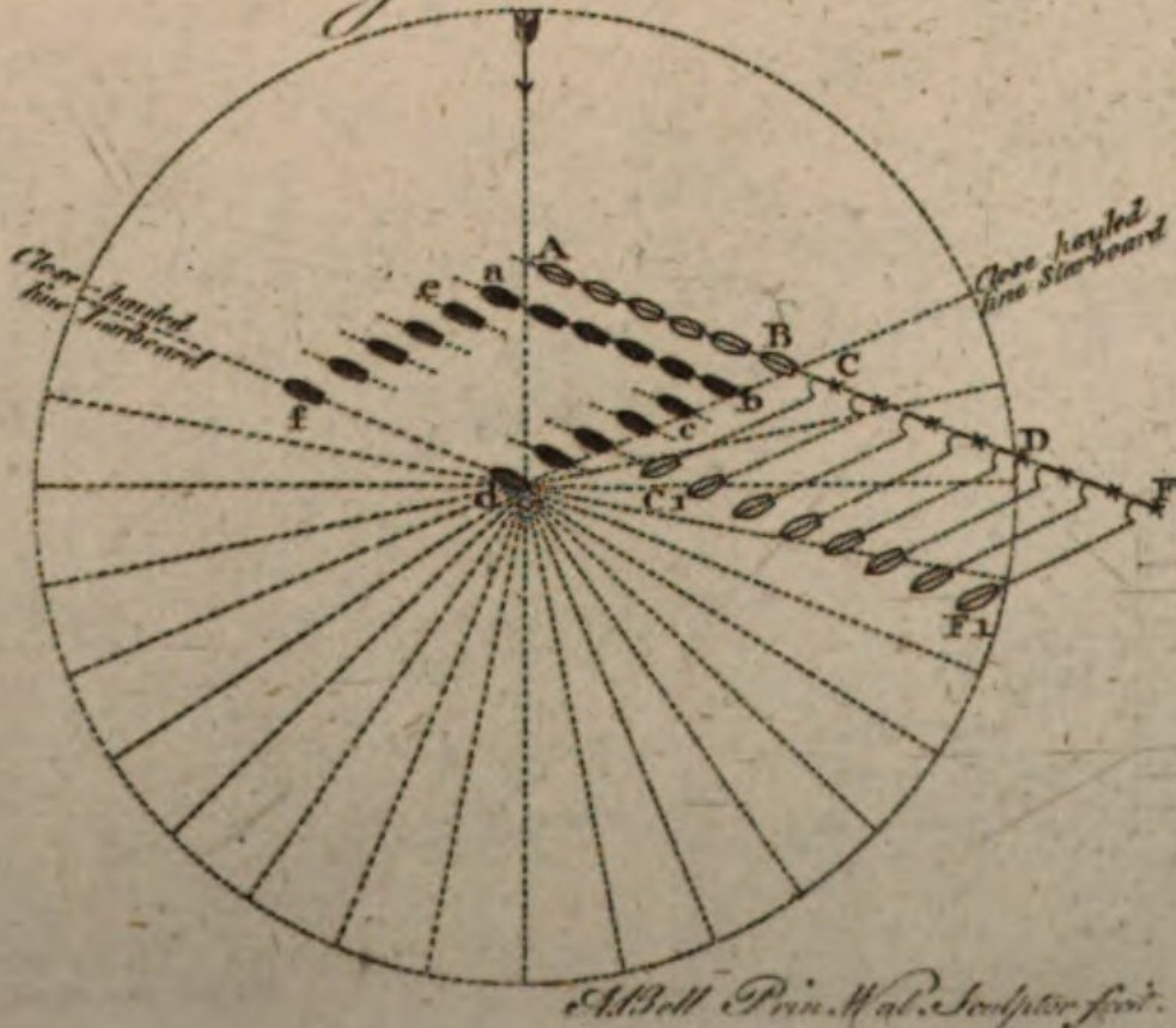


Fig. 52.

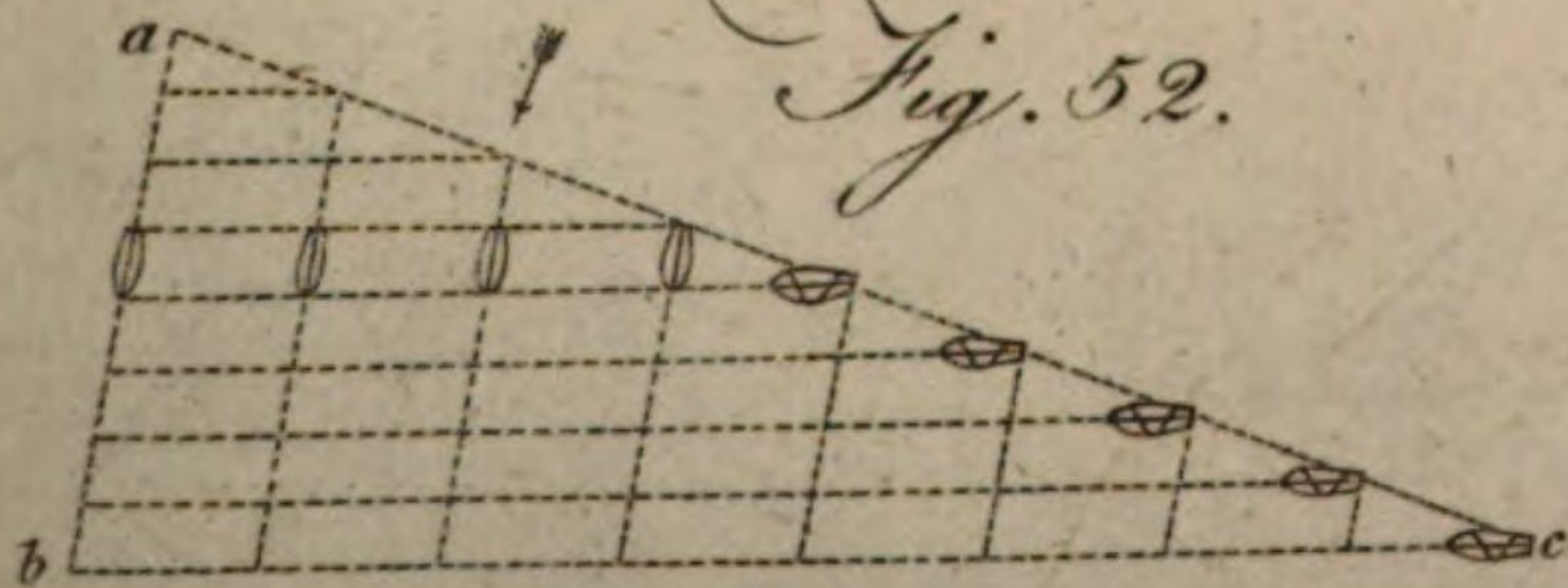


Fig. 54.

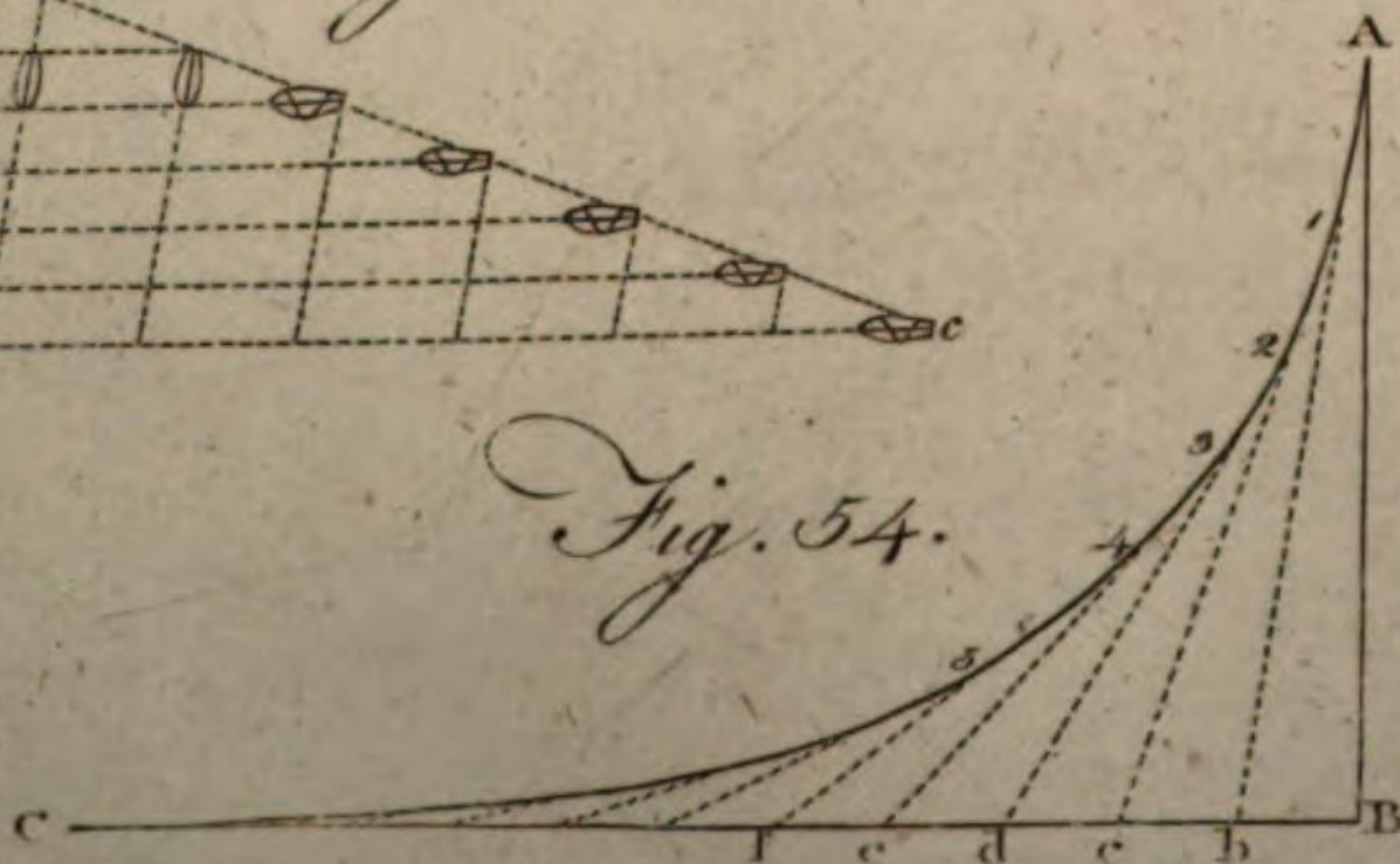


Fig. 58.

A Scale of 6 Leagues.

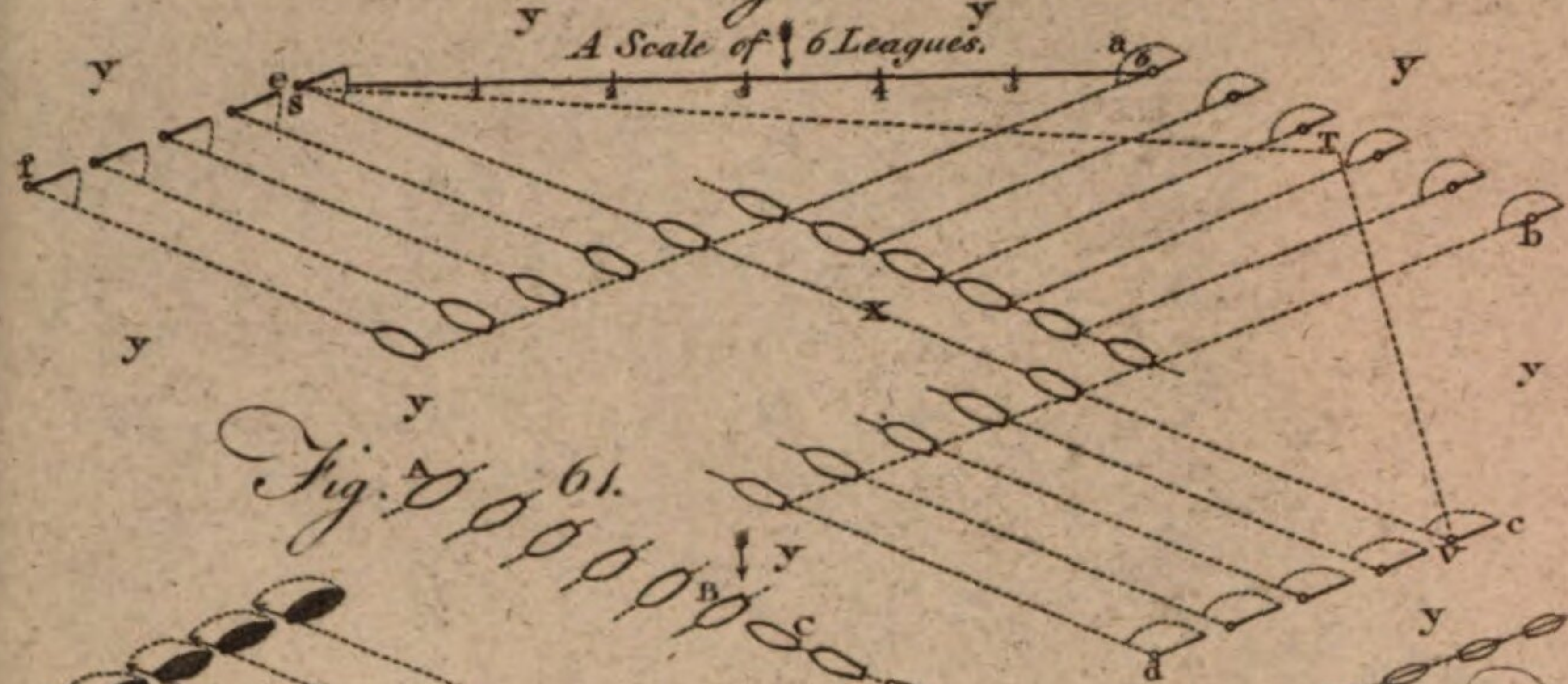


Fig. 57.



Fig. 63.

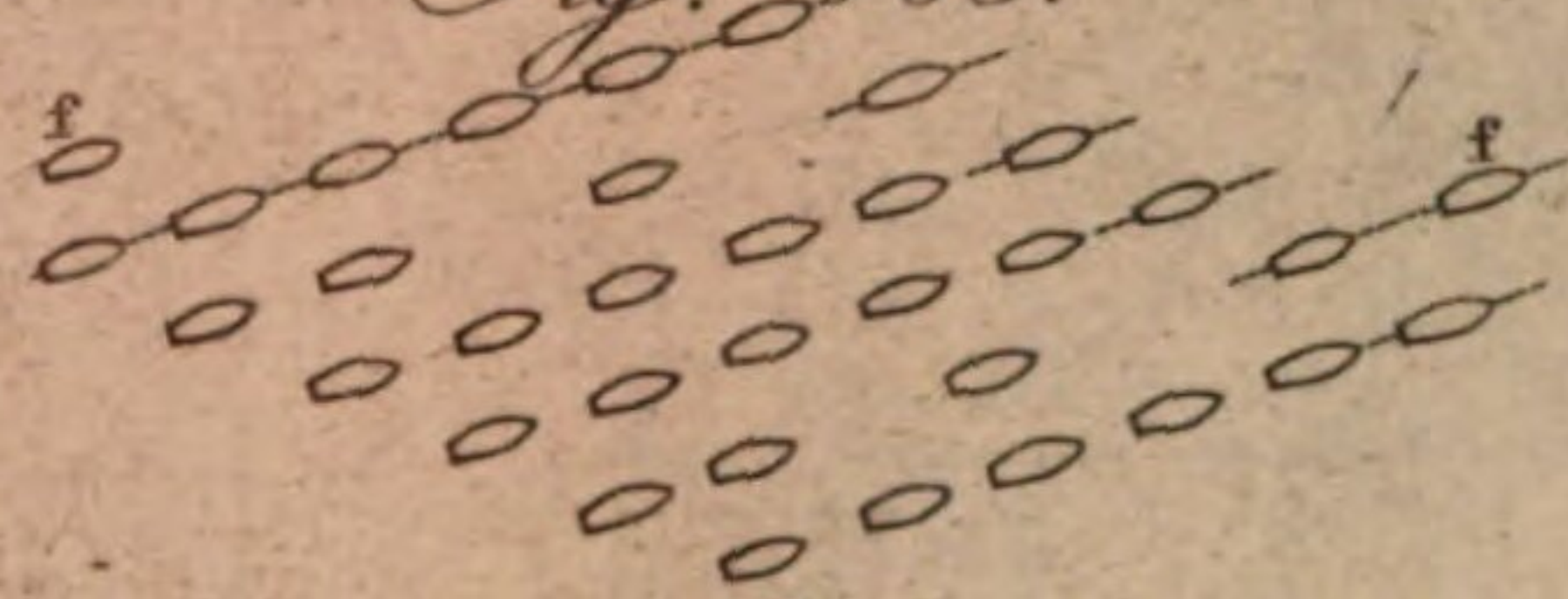


Fig. 56.

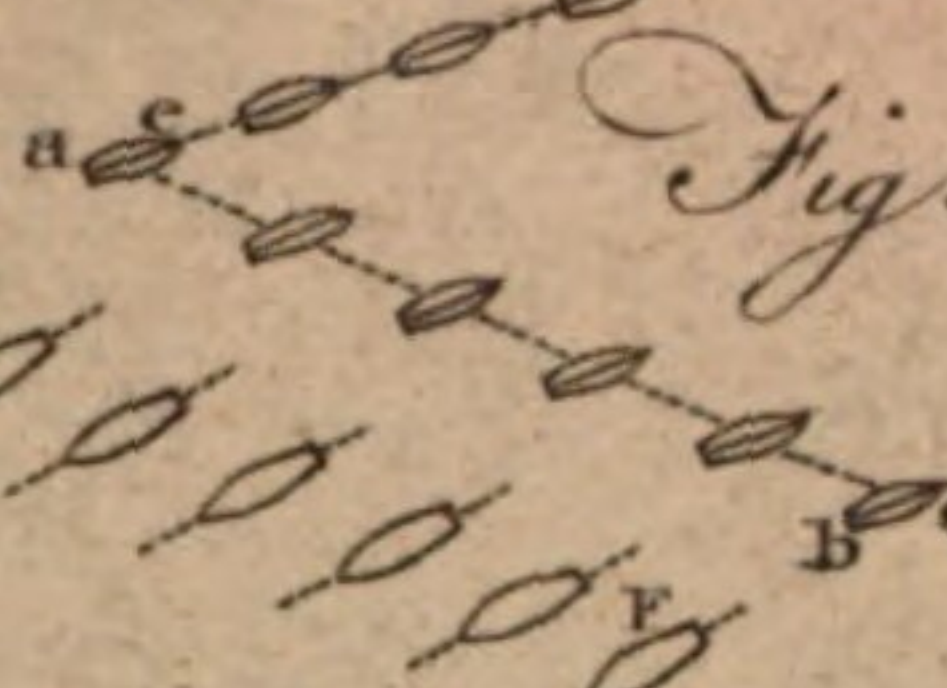


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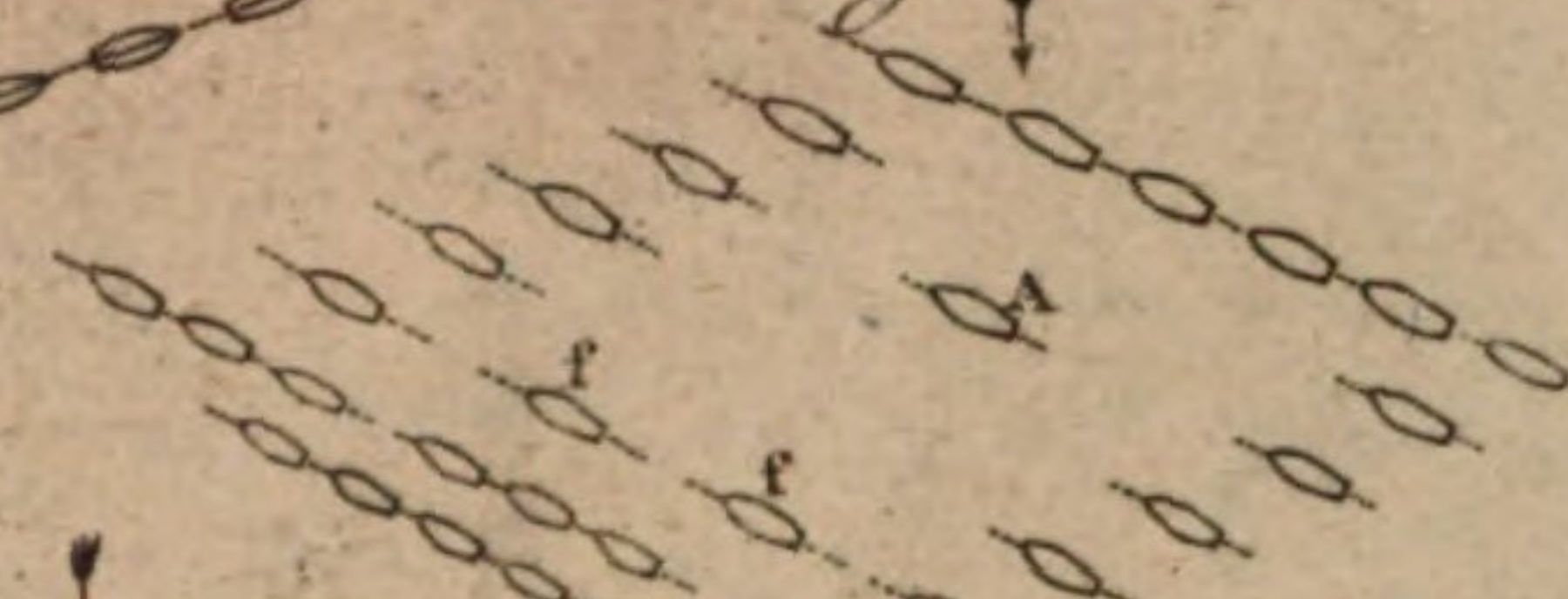


Fig. 65.

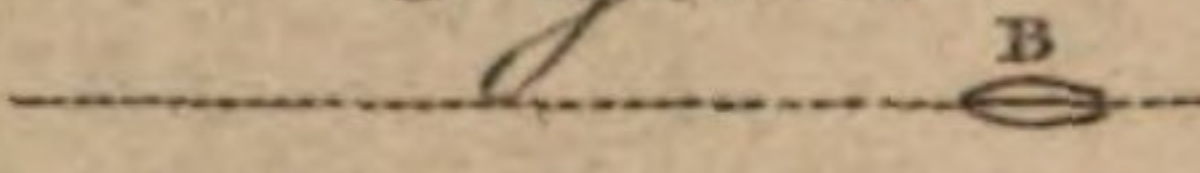


Fig. 66.



Fig. 62.

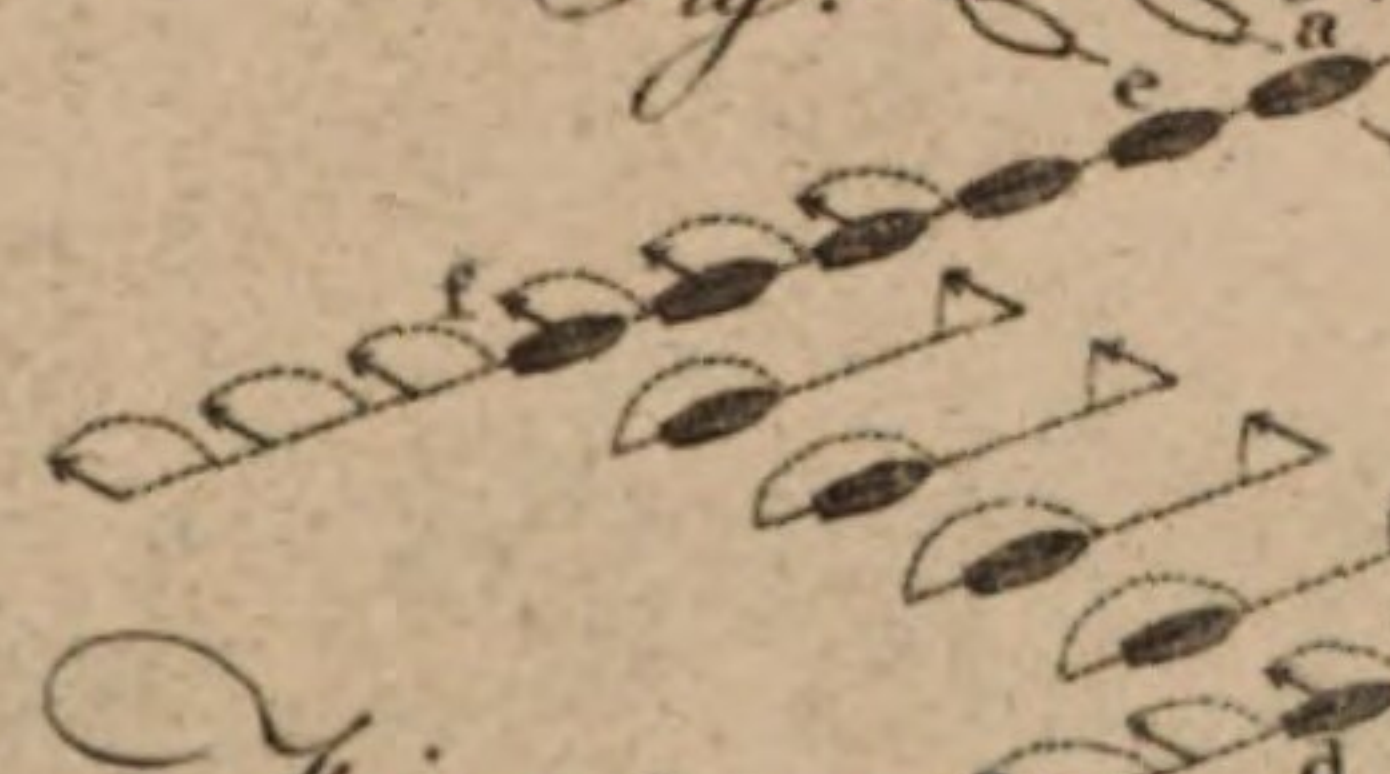


Fig. 59.

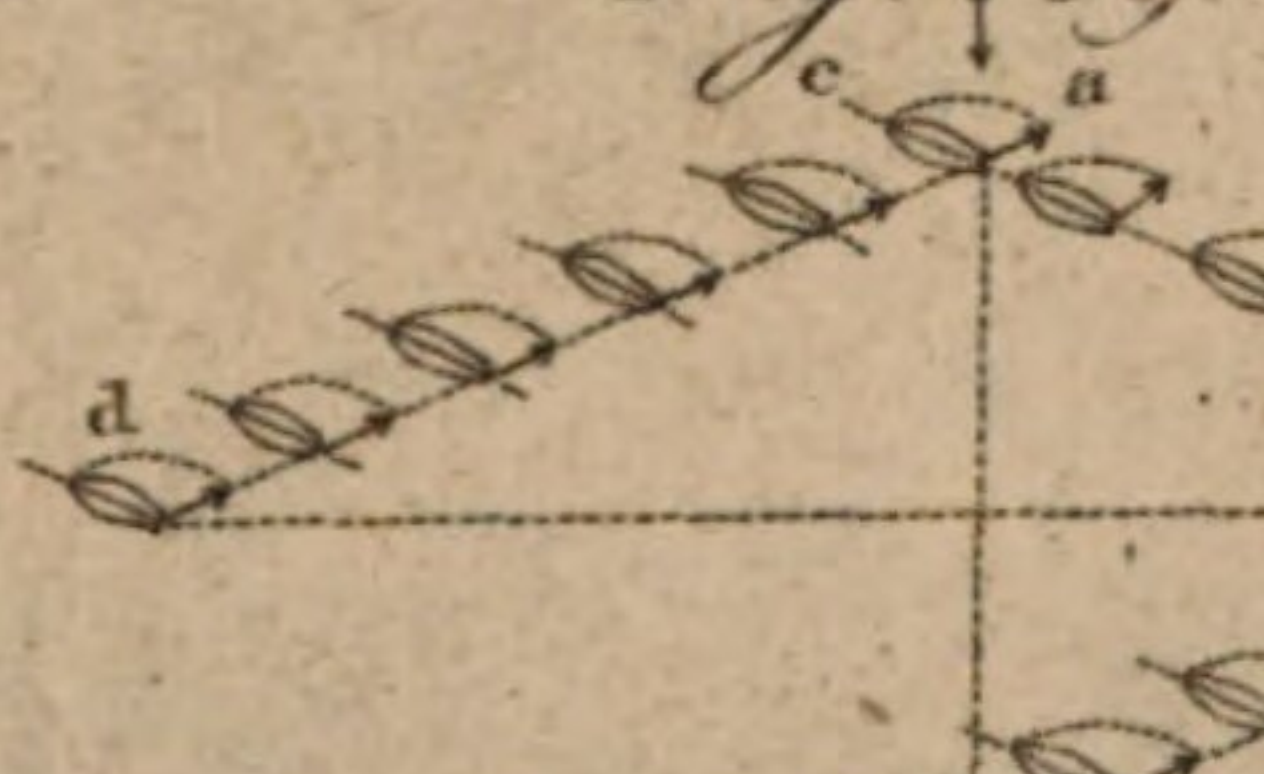


Fig. 60.



Fig. 71.

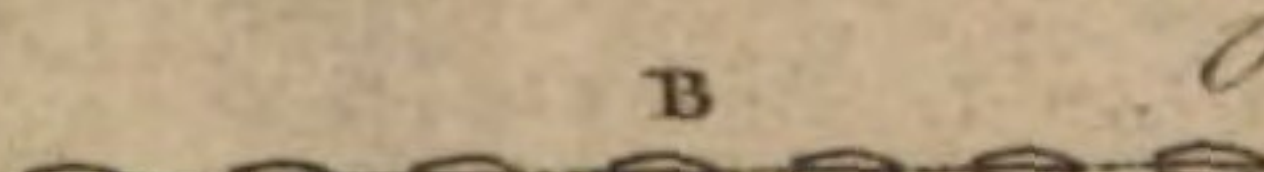


Fig. 70.

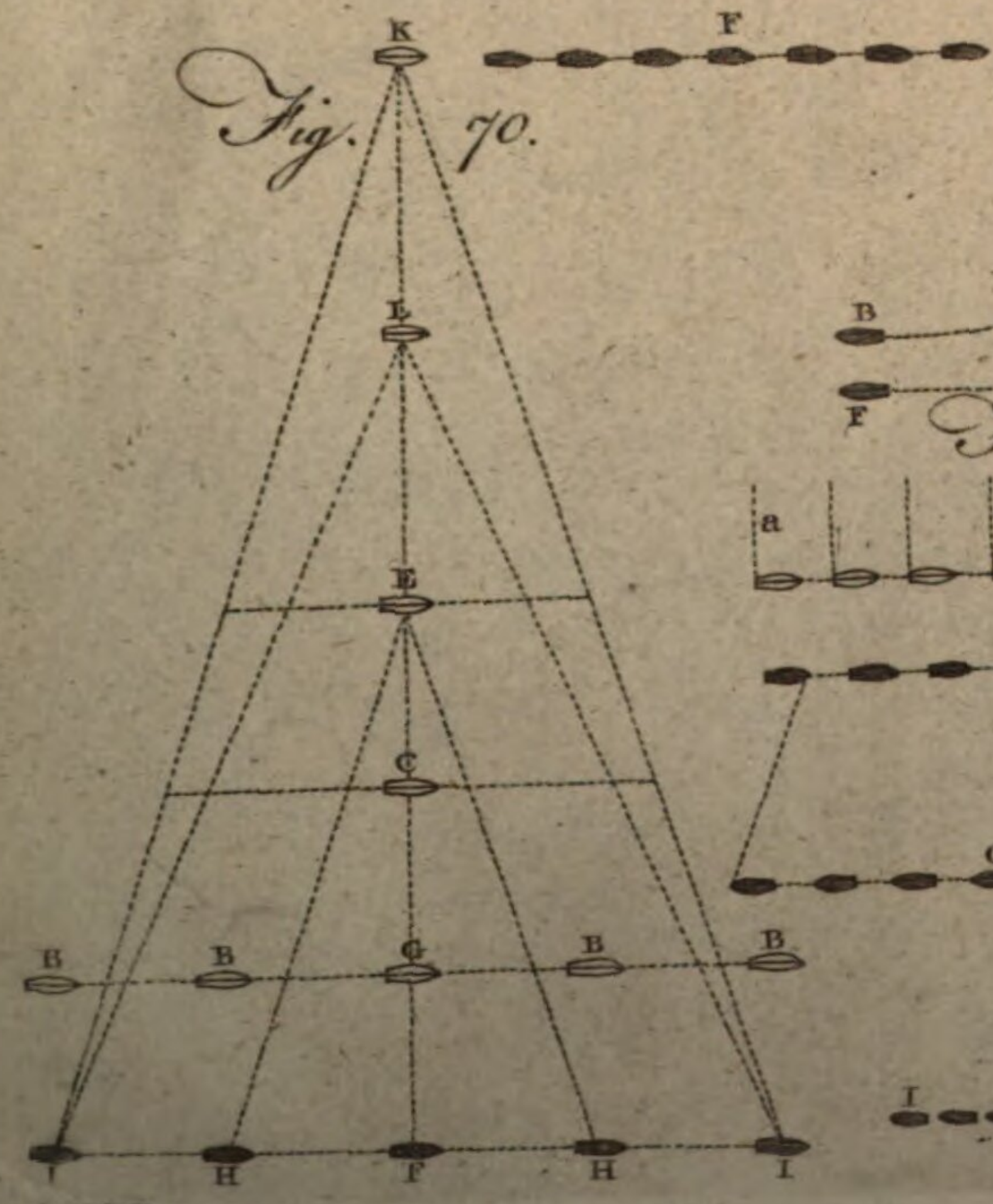


Fig. 67.

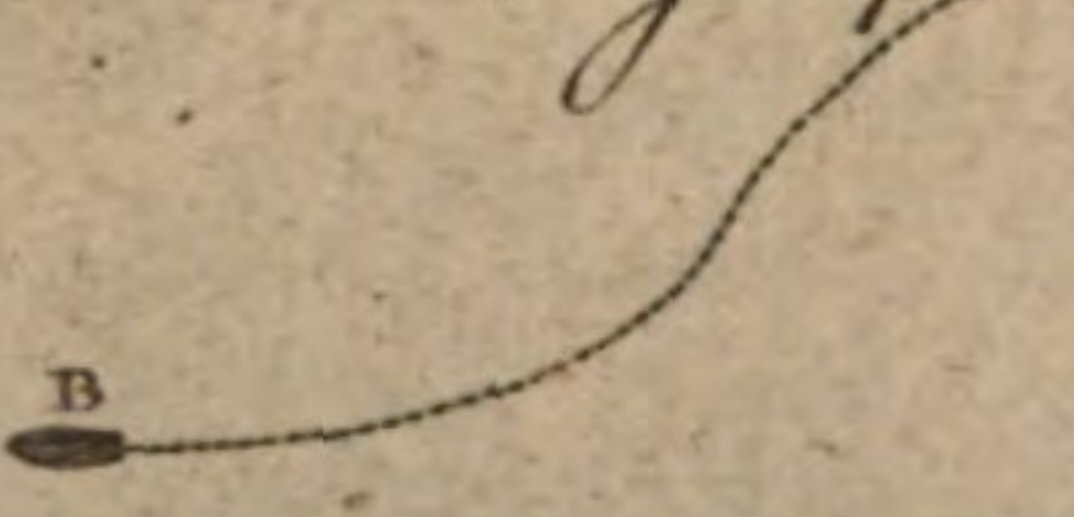


Fig. 72.

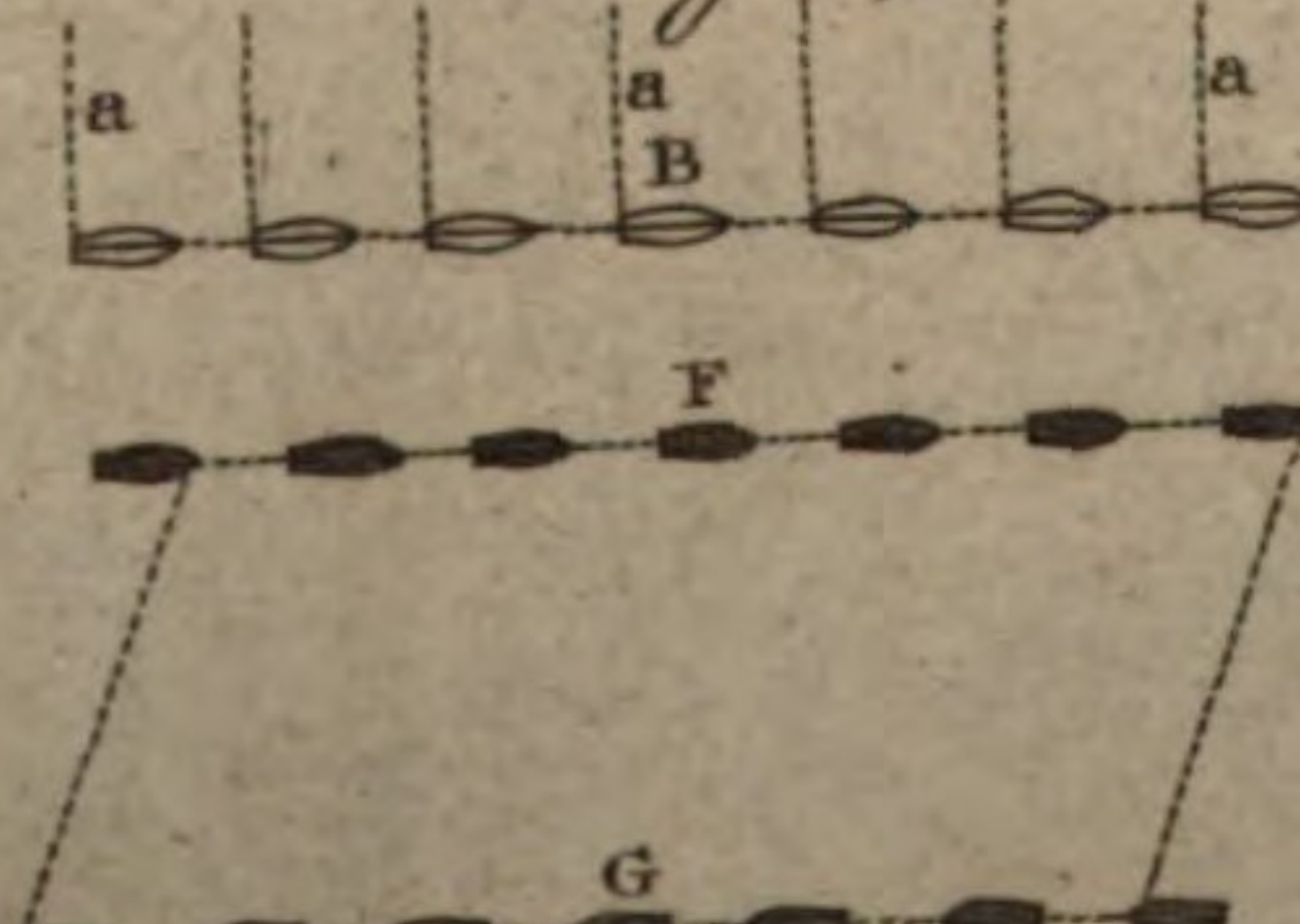


Fig. 68.

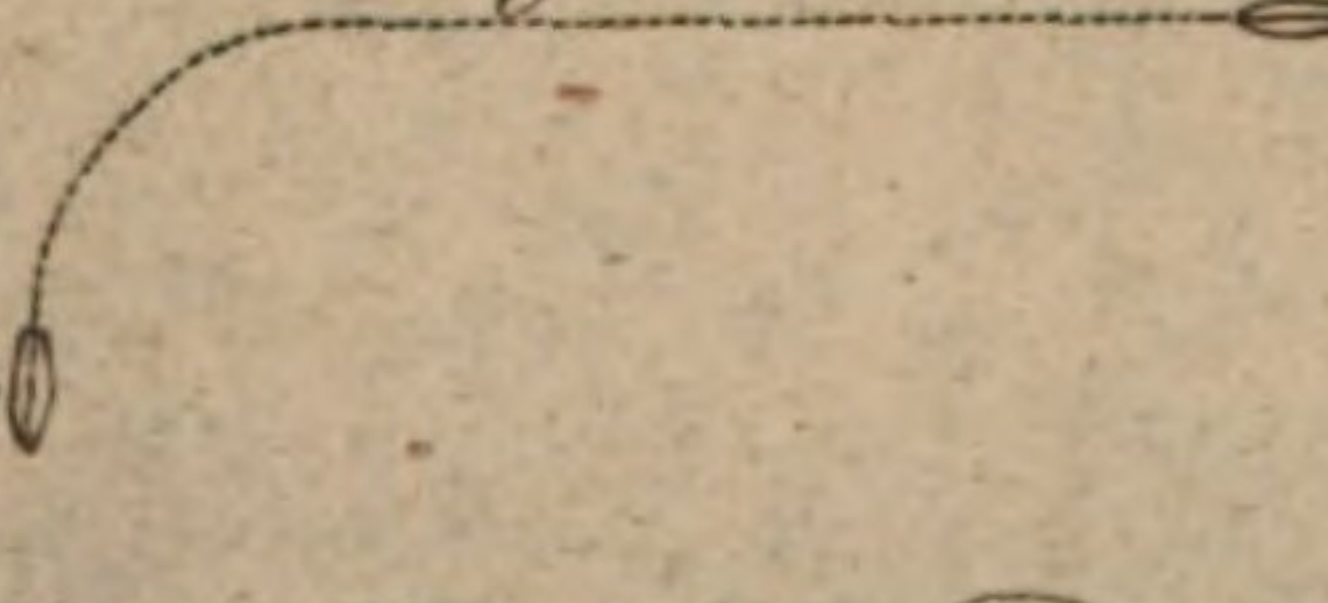


Fig. 69.

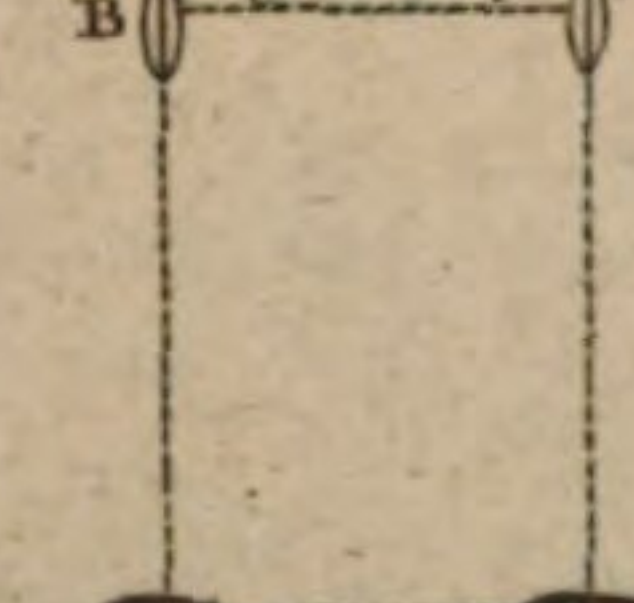


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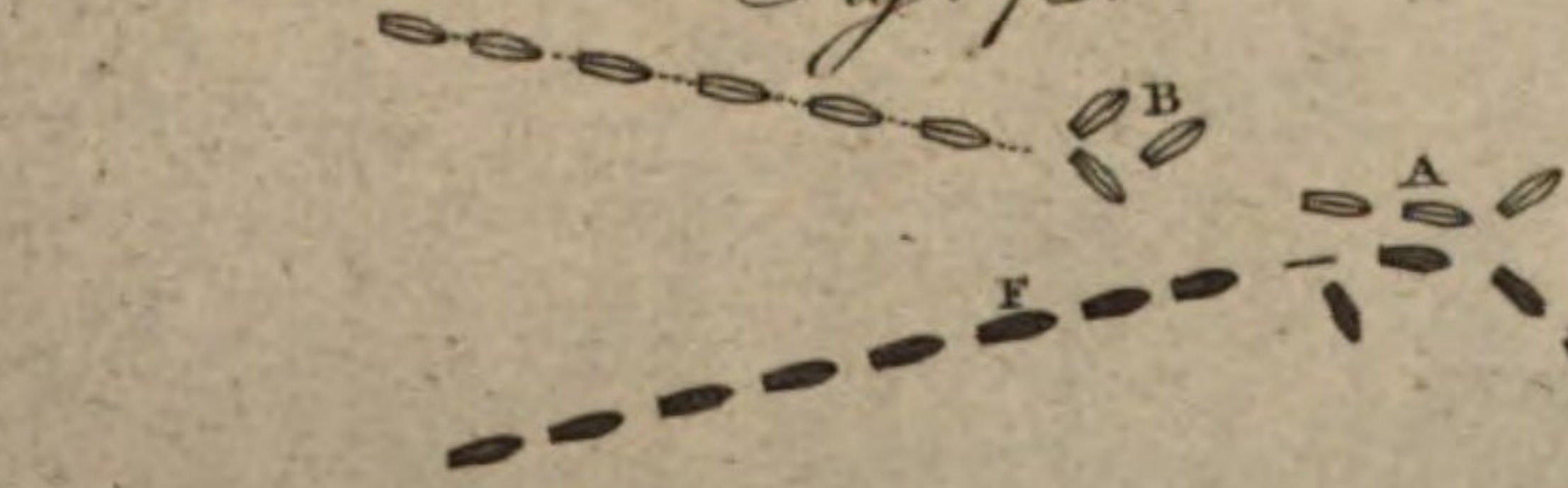


Fig. 74. No. 1.

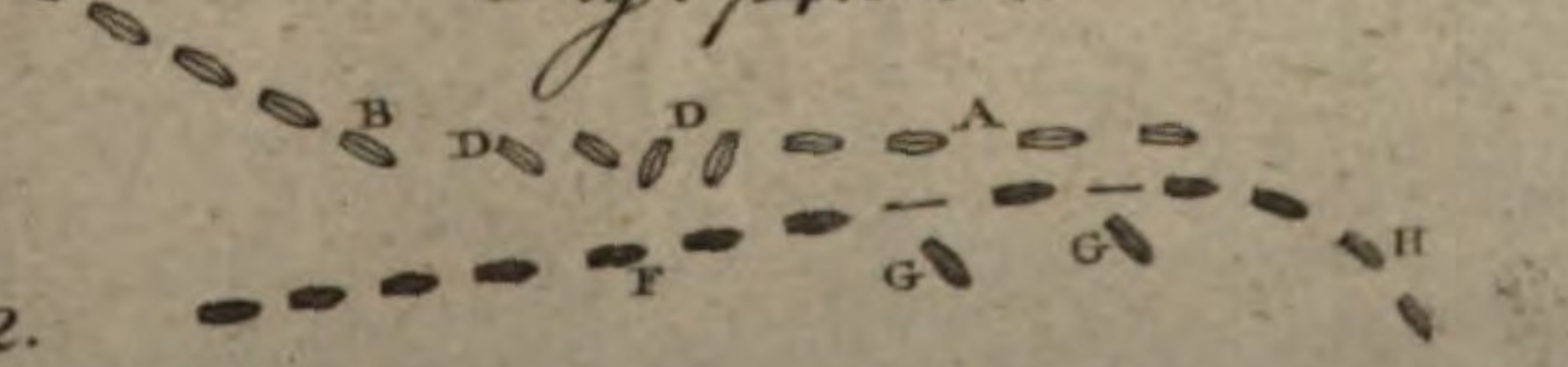


Fig. 74. No. 2.

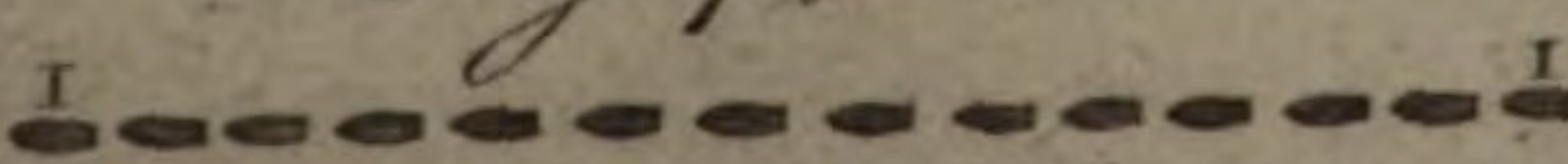


Fig. 75.

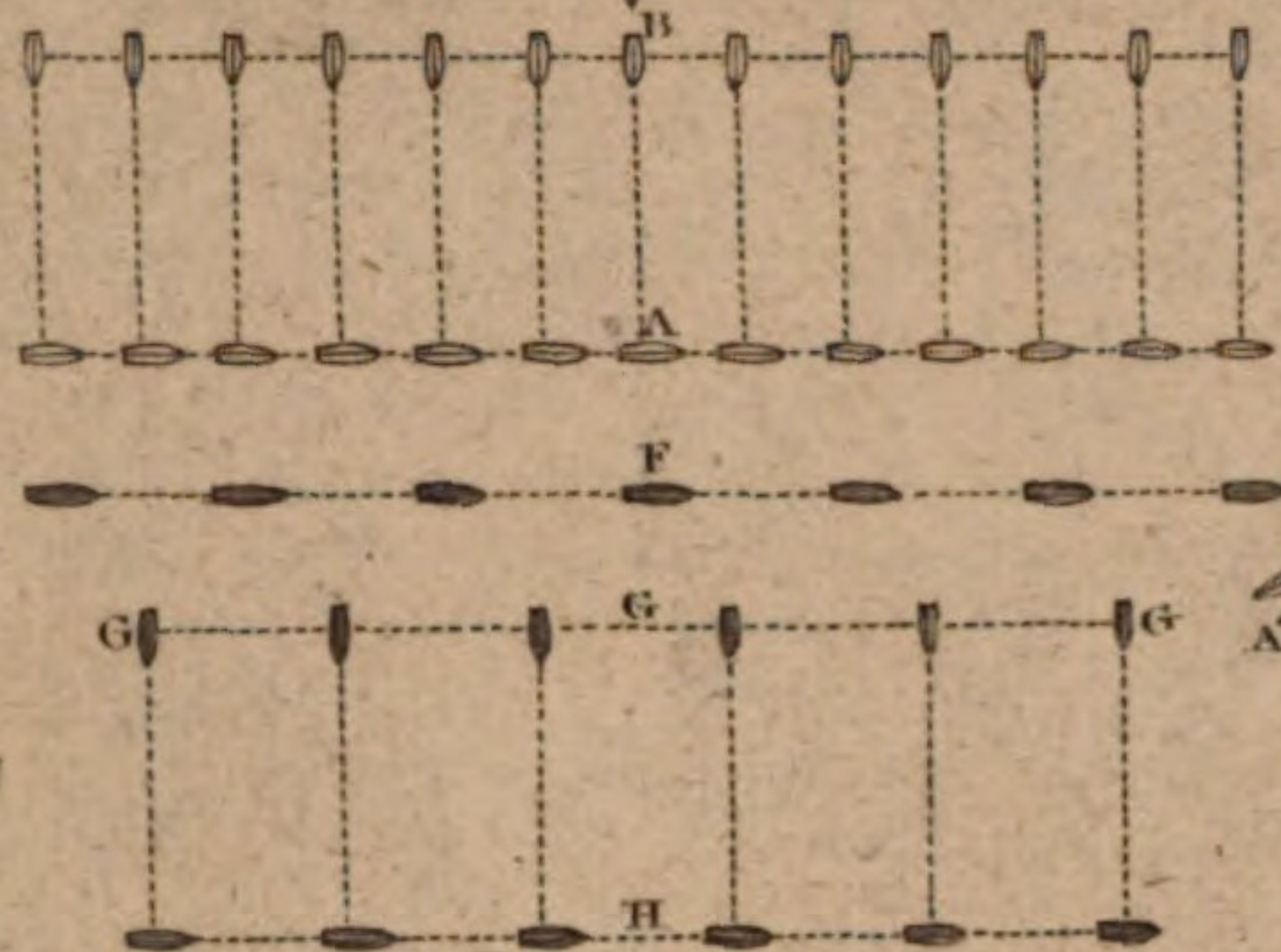


Fig. 84.

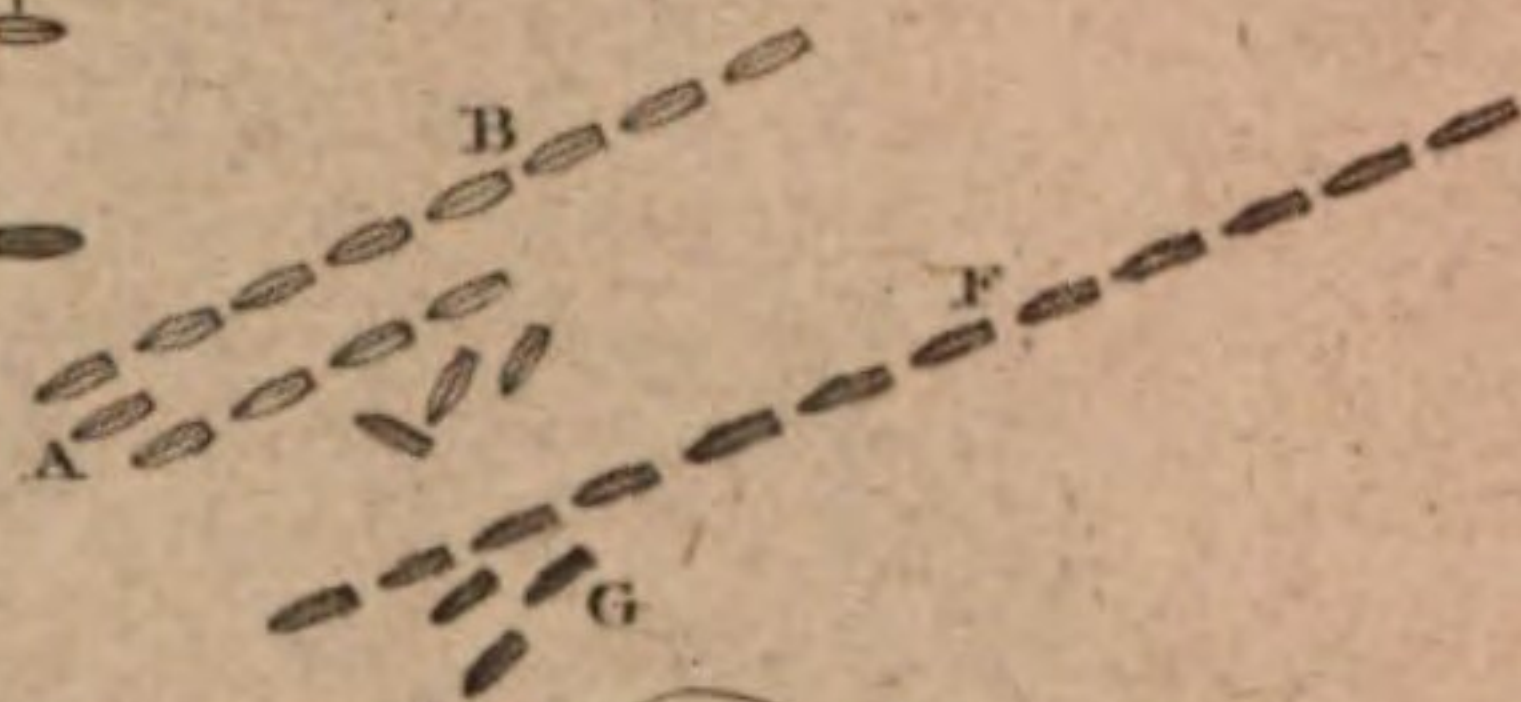


Fig. 76.

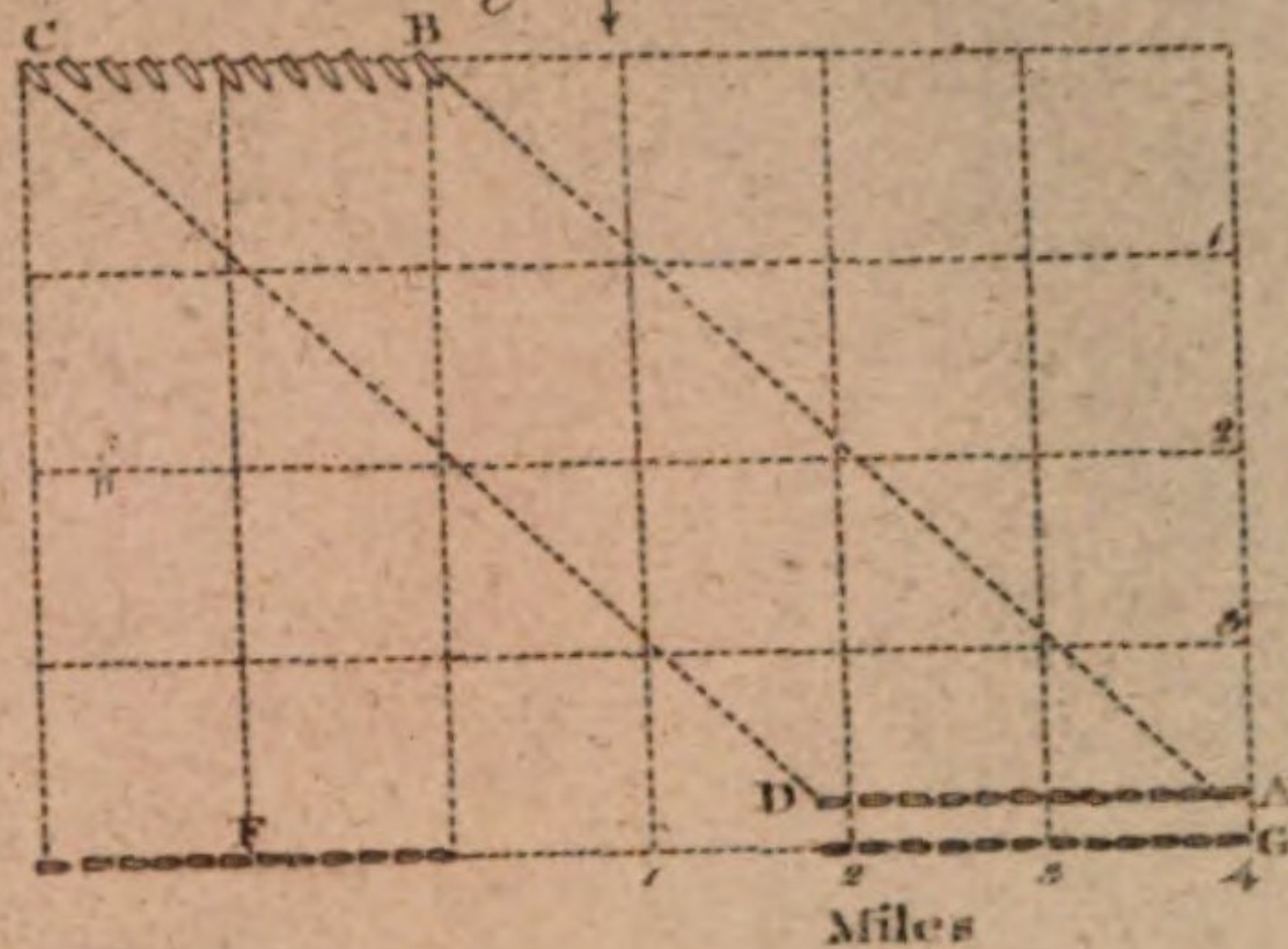


Fig. 86.



Fig. 78.

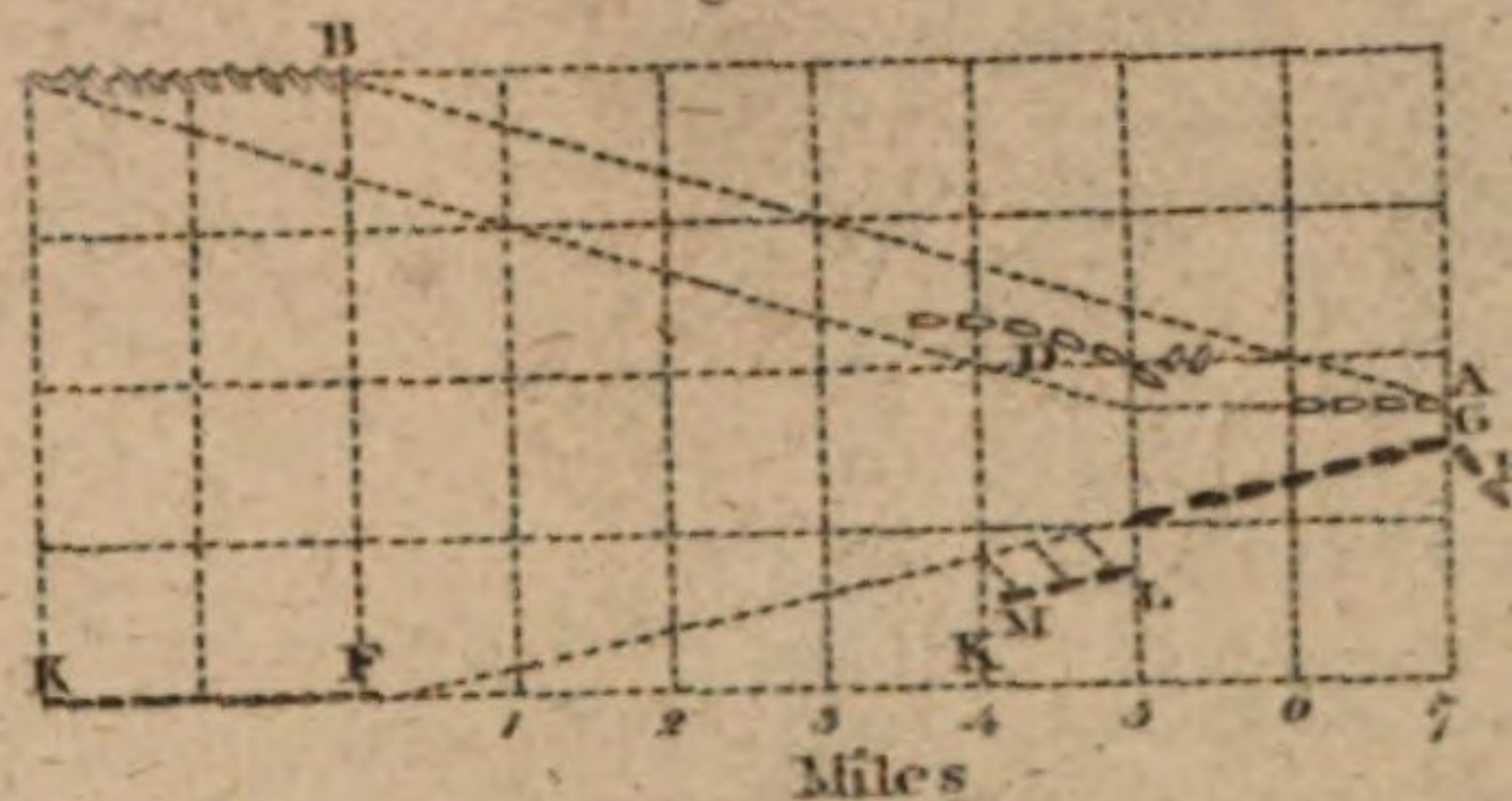


Fig. 77.

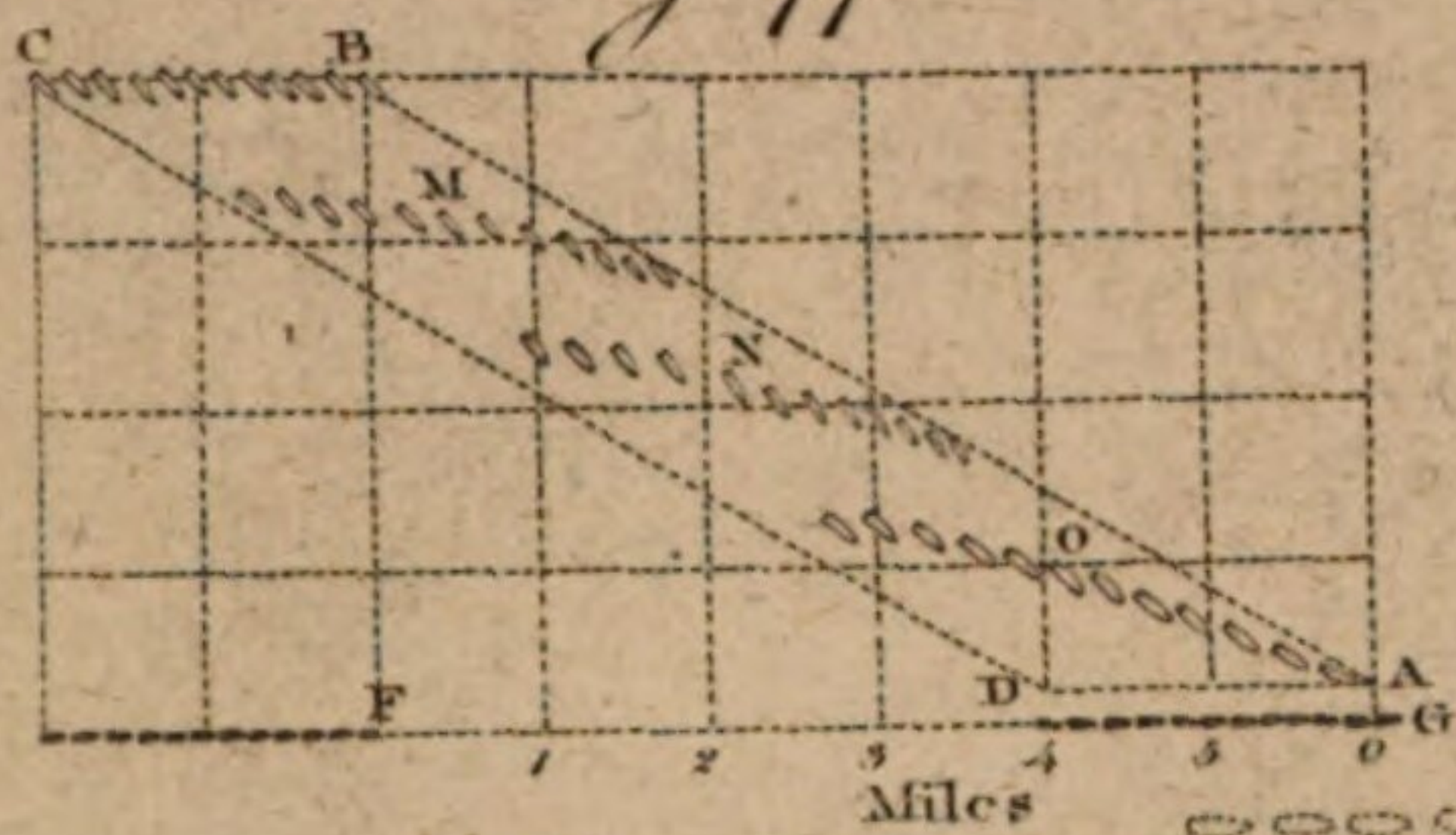


Fig. 79.

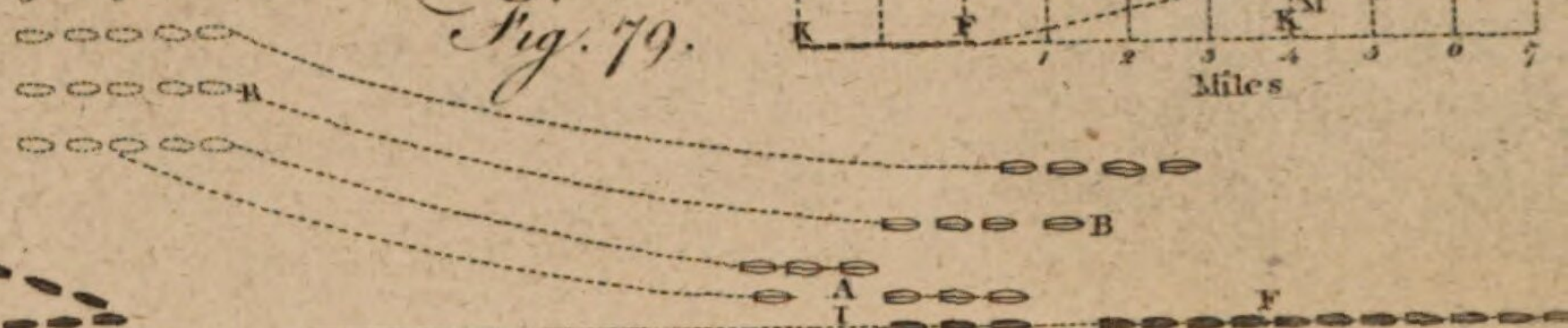


Fig. 80.



Fig. 81.

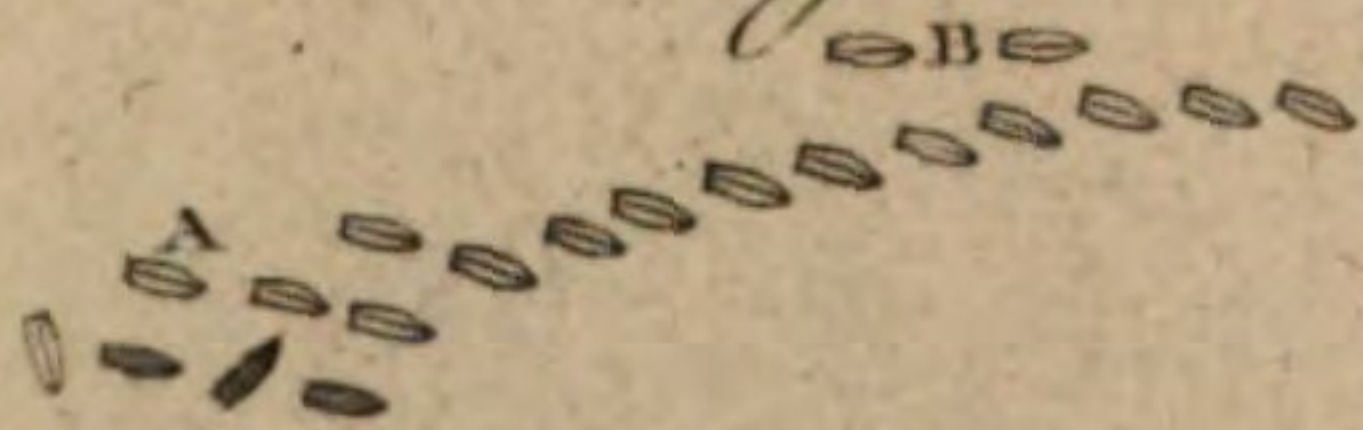


Fig. 82.



Fig. 85.

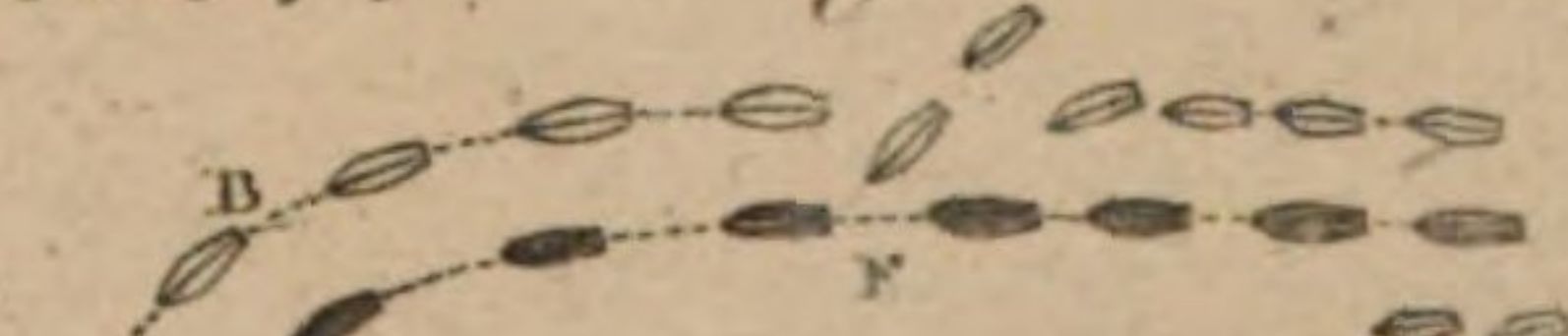


Fig. 83.



Fig. 88.

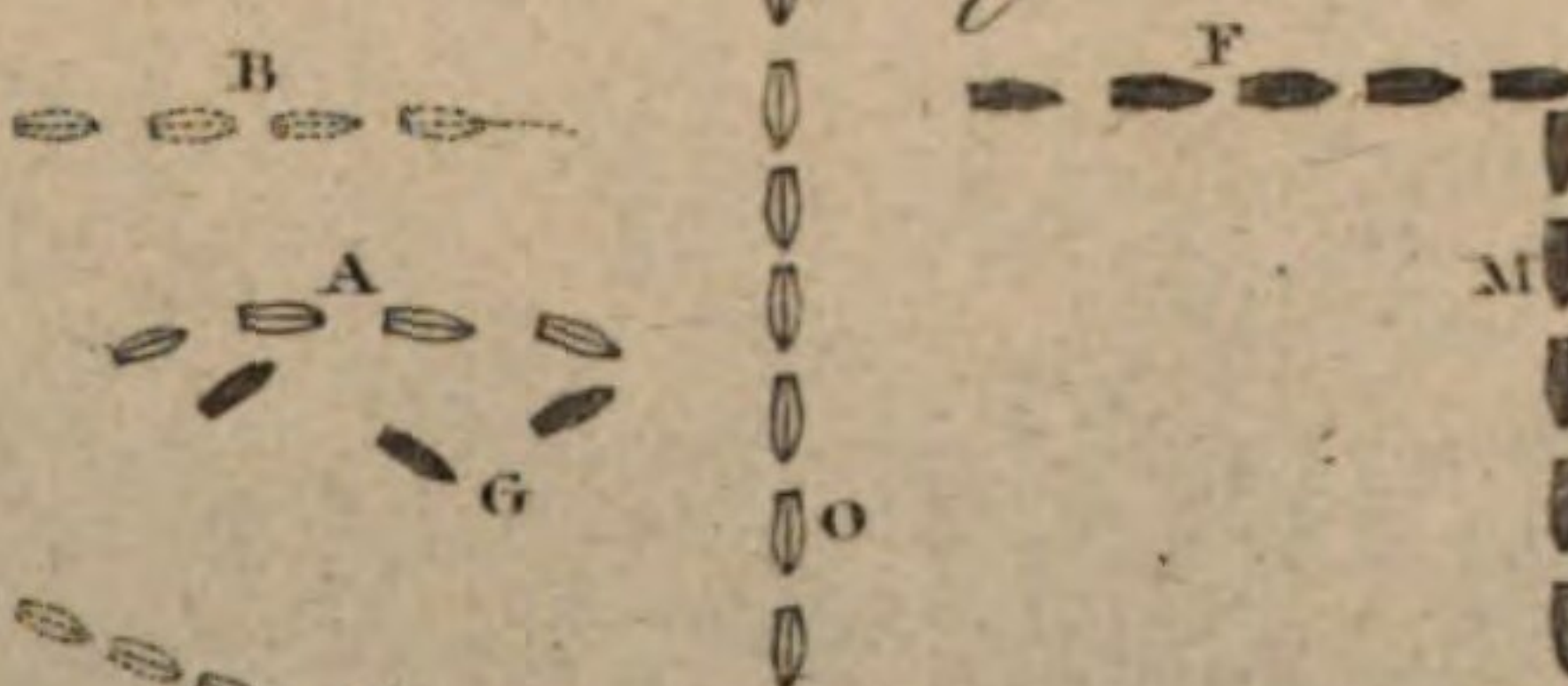


Fig. 89.

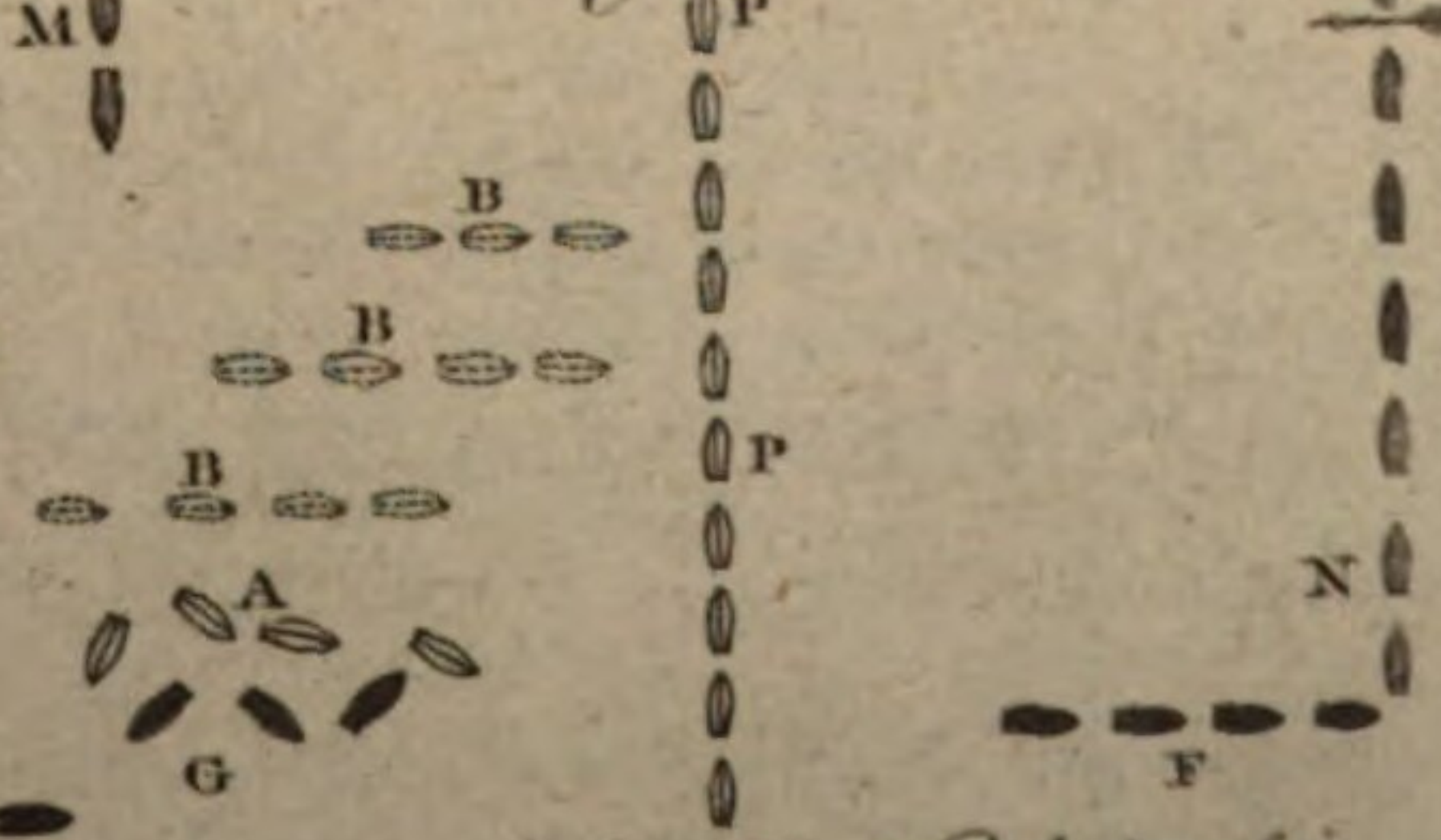


Fig. 87.

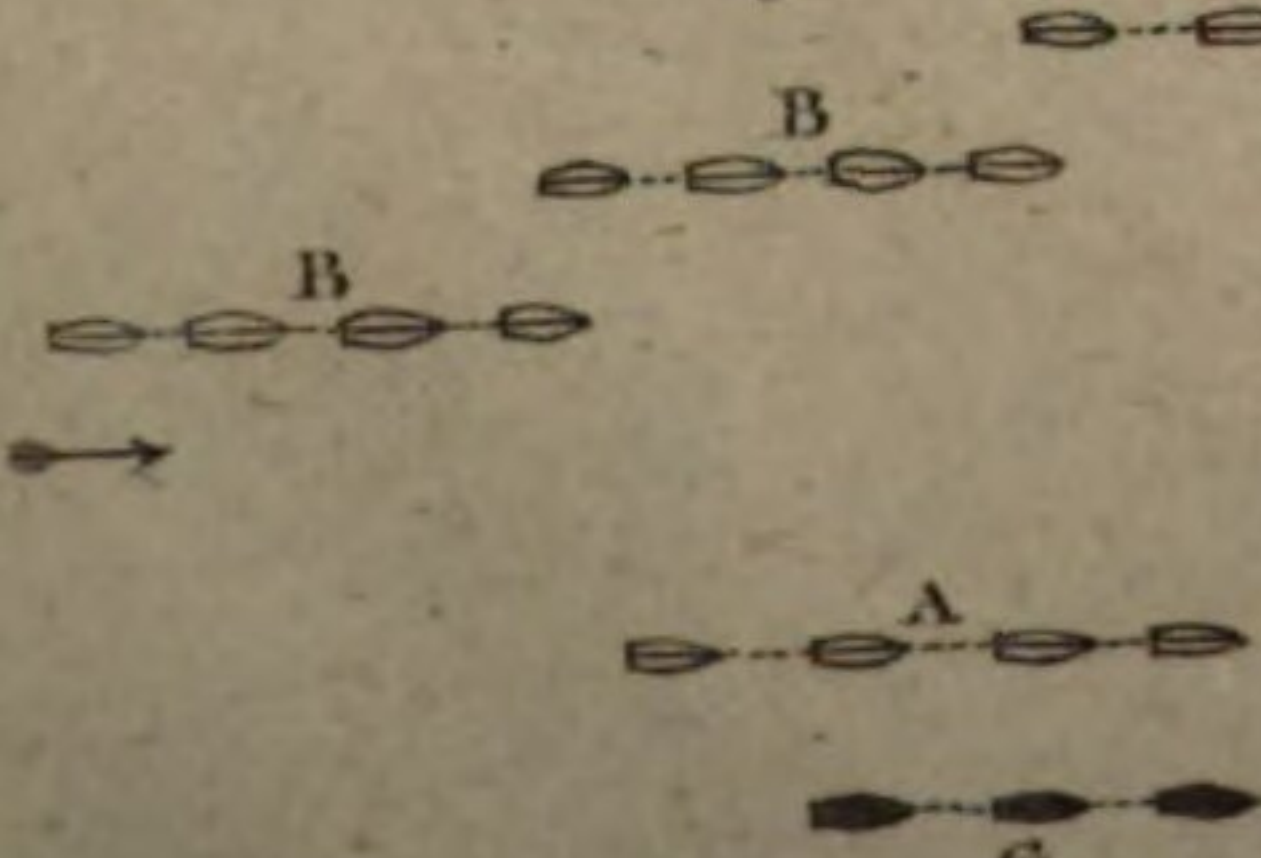
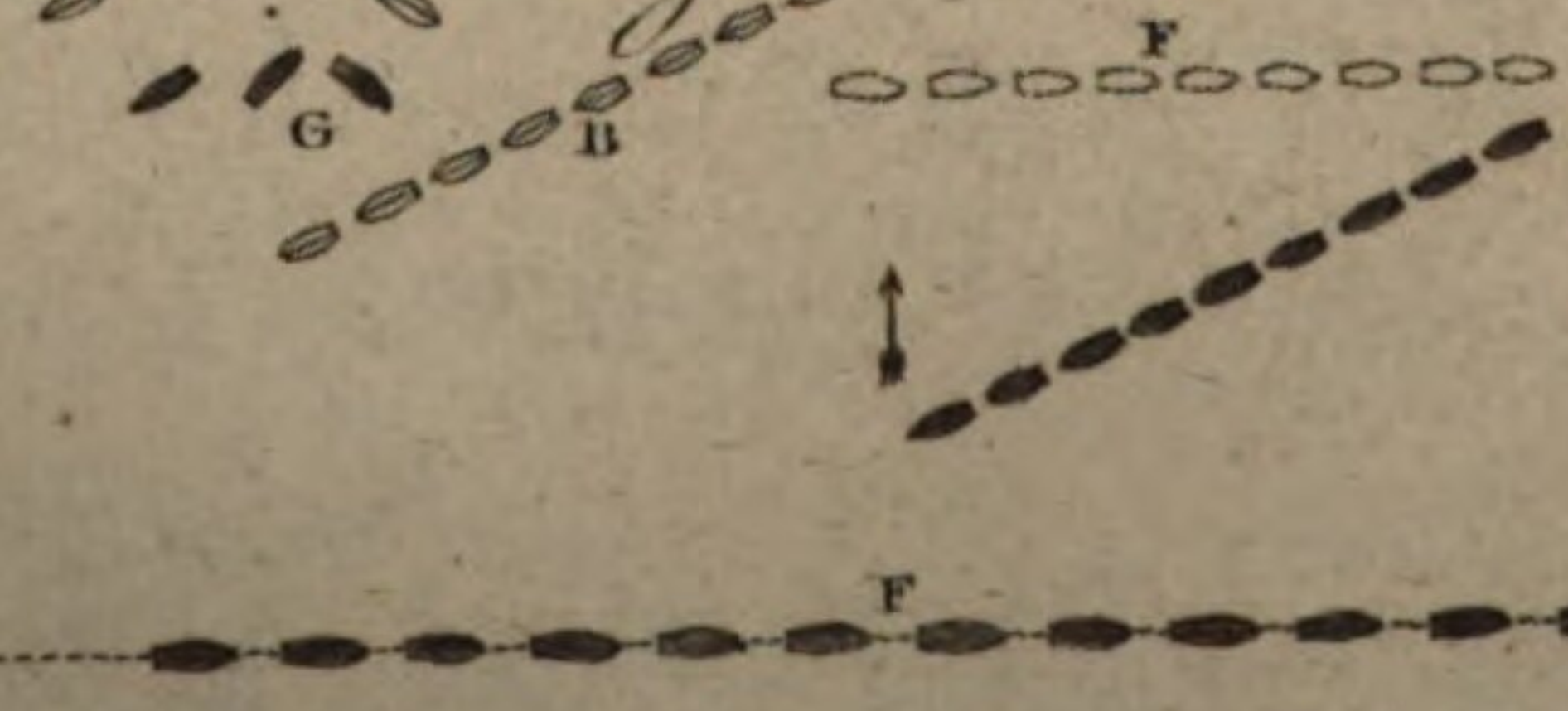


Fig. 90.



Partial
Breezes of
Wind.

Partial
Breezes of
Wind.

can be got abreast of, at a proper distance, *may be disabled, and therefore commanded*, by the numerous fresh ships kept to windward for this purpose.

In all these various methods of attack, the fleet making the attack is supposed to fail faster than the other, or at least to come up with it; and that so soon as the ships are engaged, their velocity will consequently be diminished. That being premised, a more proper mode of attack than any of the preceding will perhaps be as follows:

5th, The first or headmost of the ships intended to make the attack is to range alongside of the enemy, and preserve that station. The second ship is to make all possible sail to luff up and pass the first ship, which is now supposed to be engaged, and get alongside of the last but one of the enemy, which she is to engage. In like manner, the third of the attacking ships is to get alongside of the last but two of the enemy, whom she is to engage; and if it be deemed expedient, the fourth, &c. ship may be engaged. It is, however, evident that this method can only be practised

when the wind is brisk, and that a calm, in consequence of a vigorous cannonade, may render the attack upon more than three or four of the enemy's ships impossible.

In all the different attacks upon the rear, it has by some been thought a great object, if practicable, to throw a raking fire into the rear of an enemy's line of battle, by ships detached for that purpose. For if shot, as has been said, can take effect at a distance of two miles, from this position it will surely reach the sixth ship, if the enemy's line shall be formed at two cable's length asunder; and if formed at one cable's length asunder, it may reach and may cripple the twelfth ship.

We have now given a cursory view of Naval Tactics in its present improved state; and shall take leave of the subject, with earnestly recommending to our nautical readers Mr Clerk's Essay, which, if allowance be made for the author's peculiarity of style, will surely meet the approbation of every officer who wishes to see the practice of naval war founded on principles of science.

T Æ N

Tadcaster
||
Tænia.

TADCASTER, a town in the West Riding of Yorkshire, noted for the great plenty of limestone dug up near it; and for being one of the first places in which a building was erected for Sunday schools. It is nine miles from York, and 188 from London.

TADMOR. See **PALMYRA**.

TADPOLE, a young frog before it has disengaged itself from the membranes that envelope it in its first stage of life.

TÆNIA, in zoology; a genus of animals belonging to the class of *vermes*, and order of *intestina*. The body is long, depressed, and jointed like a chain, and contains a mouth and viscera in each joint. According to Gmelin, there are 92 species; all which inhabit the intestines of various animals, particularly of quadrupeds.

Seven species of tænia are peculiar to man. 1. The *visceralis*, which is inclosed in a vesicle, broad in the fore-part, and pointed in the hinder part, inhabits the liver, the placenta uterina, and the sack which contains the superfluous fluid of dropical persons. 2. The *cellulosa*, which is inclosed in a cartilaginous vesicle, inhabits the cellular substance of the muscles; is about an inch long, half an inch broad, and one-fourth of an inch thick, and is very tenacious of life. 3. The *dentata*, has a pointed head; the large joints are streaked transversely, and the small joints are all dilated; the osculum or opening in the middle of both margins is somewhat raised. It is narrow, 10 or 12 feet long, and broad in the fore-parts; its ovaria are not visible to the naked eye; and the head underneath resembles a heart in shape. It inhabits the intestines. 4. The *lata*, is white, with joints very short and knotty in the middle; the osculum is solitary. It is from 18 to 120 feet long; its joints are streaked transversely; its ovaria are disposed like the petals of a rose. 5. The *vulgaris*, or common tape-worm, has two lateral mouths in each joint; it attaches itself so firmly to the intestines, that it can scarcely be removed by the most violent medicines; it is slender, and has the appearance of being membranaceous; it is somewhat pellucid, from 10 to 16 feet long, and about four and an half lines broad at one end. 6. The *trutta*, which chiefly inhabits the liver of the trout, but is also to be found in the intestines of the human species. 7. The *solium*, has a marginal mouth, one on each joint.

The structure and physiology of the tænia is curious, and it may be amusing as well as instructive to consider it with more attention. As the tænia is often the occasion of dis-

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T Æ N

Tænia.

ease, we may be apt to consider it not only as useless, but even as naturally hurtful; but it is impossible to suppose that the Benevolent Father of mankind created a species of animals solely for the purpose of producing disease. The creation of the tænia is rather a striking instance of that rule which the Deity seems to have laid down to himself, to leave no place destitute of living creatures where they could multiply their species. He has therefore not only covered the earth with animals, but the surface of animals with other animals; and has even peopled such of their internal parts as could supply nourishment without disadvantage. Perhaps therefore a certain proportion of these animals is conducive to health, just as a certain proportion of different fluids is so, tho' an excessive increase always produces disease. For there is almost every different species of quadrupeds in a different species of tænia, which is a full proof that these worms have their structure and situation determined with as much attention and skill as any species of animals whatever. It is also a very curious fact, that those species of tænia which are peculiar to the human race are also peculiar to particular countries. Thus the *vulgaris* is most common in Sweden, the *lata* in Switzerland and Russia, and the *solium* in Great Britain, Saxony, and Holland.

The tænia appears destined to feed upon such juices of animals as are already animalized, and is therefore most commonly found in the alimentary canal, and in the upper part, where there is the greatest abundance of chyle; for chyle seems to be the natural food of the tænia. As it is thus supported by food which is already digested, it is destitute of the complicated organs of digestion. As the tænia solium is most frequent in this country, it may be proper to describe it more particularly,

It is from 3 to 30 feet long, some say 60 feet. It is composed of a head, in which is a mouth adapted to drink up fluids, and an apparatus for giving the head a fixed situation. The body is composed of a great number of distinct pieces articulated together, each joint having an organ whereby it attaches itself to the neighbouring part of the inner coat of the intestine. The joints nearest the head are always small, and they become gradually enlarged as they are farther removed from it; but towards the tail a few of the last joints again become diminished in size. The extremity of the body is terminated by a small semicircular joint, which has no opening in it.

The head of this animal is composed of the same kind of materials as the other parts of its body; it has a rounded

P p

open-

Tænia.

opening at its extremity, which is considered to be its mouth. See Plate DI. fig. 1, 2. This opening is continued by a short duct into two canals; these canals pass round every joint of the animal's body, and convey the aliment (fig. 3.). Surrounding the opening of the mouth are placed a number of projecting radii, which are of a fibrous texture, whose direction is longitudinal. These radii appear to serve the purpose of tentacula for fixing the orifice of the mouth, as well as that of muscles to expand the cavity of the mouth, from their being inserted along the brim of that opening: (See fig. 1.) After the rounded extremity or head has been narrowed into the neck, as is represented in fig. 2. the lower part becomes flattened, and has two small tubercles placed upon each flattened side; the tubercles are concave in the middle, and appear destined to serve the purpose of suckers for attaching the head more effectually. The internal structure of the joints composing the body of this animal is partly vascular and partly cellular; the substance itself is white, and somewhat resembles in its texture the coagulated lymph of the human blood. The alimentary canal passes along each side of the animal, sending a cross canal over the bottom of each joint, which connects the two lateral canals together. See fig. 3.

Mr Carlisle, who gives the best account of the structure and economy of the tænia which we have seen, injected with a coloured size by a single push with a small syringe three feet in length of these canals, in the direction from the mouth downwards. He tried the injection the contrary way, but it seemed to be stopped by valves. The alimentary canal is impervious at the extreme joint, where it terminates without any opening analogous to an anus. Each joint has a vascular joint occupying the middle part, which is composed of a longitudinal canal, from which a great number of lateral canals branch off at right angles. These canals contain a fluid like milk.

The tænia seems to be one of the simplest vascular animals in nature. The way in which it is nourished is singular; the food being taken in by the mouth, passes into the alimentary canal, and is thus made to visit in a general way the different parts of the animal. As it has no excretory ducts, it would appear that the whole of its alimentary fluid is fit for nourishment; the decayed parts probably dissolve into a fluid which transudes through the skin, which is extremely porous.

This animal has nothing resembling a brain or nerves, and seems to have no organs of sense but that of touch. It is most probably propagated by ova, which may easily pass along the circulating vessels of other animals. We cannot otherwise explain the phenomena of worms being found in the eggs of fowls, and in the intestines of a fœtus before birth, except by supposing their ova to have passed through the circulating vessels of the mother, and by this means been conveyed to the fœtus.

The chance of an ovum being placed in a situation where it will be hatched, and the young find convenient subsistence, must be very small; hence the necessity for their being very prolific. If they had the same powers of being prolific which they now have, and their ova were afterwards very readily hatched, then the multiplication of these animals would be immense, and become a nuisance to the other parts of the creation.

Another mode of increase allowed to tænia (if we may call it increase) is by an addition to the number of their joints. If we consider the individual joints as distinct beings, it is so; and when we reflect upon the power of generation given to each joint, it makes this conjecture the more probable. We can hardly suppose that an ovum of a tænia, which at its full growth is 30 feet long, and composed of

400 joints, contained a young tænia composed of this number of pieces; but we have seen young tænia not half a foot long, and not possessed of 50 joints, which still were entire worms. We have also many reasons to believe, that when a part of this animal is broken off from the rest, it is capable of forming a head for itself, and becomes an independent being. The simple construction of the head makes its regeneration a much more easy operation than that of the tails and feet of lizards, which are composed of bones and complicated vessels; but this last operation has been proved by the experiments of Spallanzani and many other naturalists.

When intestinal worms produce a diseased state of the animal's body which they inhabit, various remedies are advised for removing them; many of which are ineffectual, and others very injurious by the violence of their operation. Drastic purges seem to operate upon tænia, partly by irritating the external surface of their bodies, so as to make them quit their holds, and partly by the violent contractions produced in the intestine, which may sometimes divide the bodies of tænia, and even kill them by bruising. Mr Carlisle proposes the trial of a simple remedy, which (*à priori*) promises to be successful; namely, small shocks of electricity passed frequently through the regions of the abdomen; the lives of the lower orders of animals seeming to be easily destroyed by such shocks of electricity as do not injure the larger and more perfect animals.

Plate DI. fig. 1. shows the head of the tænia magnified; the mouth is in the middle of the circular plane, where the body becomes flattened and broad; there are two hollow tubercles represented by the two dark shaded spots. Fig. 2. is the same head, of its natural bigness, and which belonged to a tænia 20 feet in length. Fig. 3. shows the alimentary canals, in a portion of the same tænia, of their natural bigness. The dark-shaded undulating lines are the alimentary canals, which are seen to their full extent in this portion of the worm. Fig. 4. shows the middle system of vessels, in two joints, which are represented by the dark lines. Fig. 5. shows two joints, from one side of which a slip was torn down to show the vessels underneath, and also the direction of the fibres in the slip, which are accumulated into little fasciculi like muscular fibres. Fig. 6. exhibits three joints, having the ducts leading from the lateral oscula injected; the dark transverse lines leading from each osculum show the size, direction, and extent of these ducts. Fig. 7. shows the edge of two joints turned forwards, and the appearance of the oscula in this point of view. Fig. 8. represents the whole of these canals in their relative situations.

For a more complete account of the tænia, we must refer to Mr Carlisle's ingenious paper in the Linnæan Transactions.

TAFFETY or TAFFETA, in commerce, a fine smooth filken stuff, remarkably glossy. There are taffeties of all colours, some plain, and others striped with gold, silver, &c. others chequered, others flowered, &c. according to the fancy of the workmen.

TAGARA, a city of ancient India, the metropolis of a large district called *Ariaca*, which comprehended the greatest part of the Subah of Aurangabad, and the southern part of Concan. Arrian says, that it was situated about ten days journey to the eastward of Pultanah; which, according to the rate of travelling in that country with loaded carts, might be about 100 British miles. This fixes its situation at Deoghir, a place of great antiquity, and famous through all India on account of the pagodas of Eloufa. It is now called *Douletabad*.

TAGETES, MARYGOLD, in botany: A genus of plants belonging to the class of *syngenesia*, and order of *polygamia superflua*; and in the natural system ranging under the 49th order,

Tænia
||
Tagetes.

Tagetes
||
Tail.

order, *Compositæ*. The receptacle is naked; the pappus consists of five erect awns or beards; the calyx is monophyllous, quinque-dentate, and tubular; and there are four persistent florets of the ray. There are three species, the *patula*, *erecta*, and *minuta*; of which the two first have been cultivated in the British gardens, at least, since the year 1596, for it is mentioned in Gerard's Herbal, which was published that year. They are both natives of Mexico.

The *erecta*, or African marygold, has a stem subdivided and spreading, and has formed itself into a great many varieties: 1. Pale yellow, or brimstone colour, with single, double, and fistulous flowers. 2. Deep yellow, with single, double, and fistulous flowers. 3. Orange-coloured, with single, double, and fistulous flowers. 4. Middling African, with orange-coloured flowers. 5. Sweet-scented African. These are all very subject to vary; so that unless the seeds are very carefully saved from the finest flowers, they are apt to degenerate: nor should the same seeds be too long sown in the same garden, for the same reason; therefore, those who are desirous to have these flowers in perfection should exchange their seeds with some person of integrity at a distance, where the soil is of a different nature, at least every other year. If this is done, the varieties may be continued in perfection. This plant is so well known as to need no description. It flowers from the beginning of July till the frost puts a stop to it.

The *patula* has a simple erect stem, and the peduncles are scaly and multiflorous.

It has been long in the British gardens, where it is distinguished from the first by the title of *French marygold*. Of this there are several varieties, some of which have much larger flowers than others, and their colour varies greatly: there are some which are beautifully variegated, and others quite plain; but as these are accidents arising from culture, so they do not merit farther distinction; for we have always found that seeds saved from the most beautiful flowers will degenerate, especially if they are sown in the same garden for two or three years together, without changing the seed.

These plants have a strong disagreeable scent, especially when handled; for which reason they are not so greatly esteemed for planting near habitations: but the flowers of the sweet-scented sort being more agreeable, are generally preferred, especially for planting in small gardens.

TAGUS, the largest river of Spain; which, taking its rise on the confines of Arragon, runs south-west through the provinces of New Castile and Estremadura; and passing by the cities of Aranjuez, Toledo, and Alcantara, and then crossing Portugal, forms the harbour of Lisbon, at which city it is about three miles over; and about eight or ten miles below this it falls into the Atlantic ocean.

TAHOERWA, one of the Sandwich islands. It is small, destitute of wood, and its soil sandy and unfertile. It is situated in north latitude $20^{\circ} 38'$, in east longitude $203^{\circ} 27'$. See *Cook's Discoveries*, vol. v. n^o 88. and *SANDWICH-Islands*.

TAHOORA, one of the Sandwich islands in the South Sea. It is uninhabited, and lies in north latitude $21^{\circ} 43'$, and in east longitude $199^{\circ} 36'$. See *SANDWICH-Islands*.

TAJACU, or PECCARY, in zoology, a species of hog. See *Sus*.

TAI-OUAN, the Chinese name of the island of Formosa. See *FORMOSA*.—Tai-ouan is also the name of the capital of the island.

TAIL, the train of a beast, bird, or fish; which in land animals serves to drive away flies, &c. and in birds and fishes to direct their course, and assist them in ascending or descending in the air or water.

TAIL, or FEE-TAIL, in law, is a conditional estate or fee, opposed to *fee-simple*. See *FEE*.

A conditional fee, at the common law, was a fee restrained to some particular heirs exclusive of others: as to the heirs of a man's body, by which only his lineal descendants were admitted, in exclusion of collateral heirs; or to the heirs male of his body, in exclusion both of collaterals and lineal females also. It was called a *conditional fee*, by reason of the condition expressed or implied in the donation of it, that if the donee died without such particular heirs, the land should revert to the donor. For this was a condition annexed by law to all grants whatsoever, that on failure of the heirs specified in the grant, the grant should be at an end, and the land return to its ancient proprietor. Such conditional fees were strictly agreeable to the nature of feuds, when they first ceased to be mere estates of life, and were not yet arrived to be absolute estates in fee-simple.

With regard to the condition annexed to these fees by the common law, it was held, that such a gift (to a man and the heirs of his body) was a gift upon condition that it should revert to the donor if the donee had no heirs of his body; but if he had, it should then remain to the donee. They therefore called it a *fee-simple* on condition that he had issue. Now we must observe, that when any condition is performed, it is thenceforth entirely gone; and the thing to which it was before annexed becomes absolute and wholly unconditional. So that as soon as the grantee had any issue born, his estate was supposed to become absolute by the performance of the condition; at least for these three purposes: 1. To enable the tenant to alienate the land, and thereby to bar not only his own issue, but also the donor, of his interest in the reversion. 2. To subject him to forfeit it for treason: which he could not do till issue born longer than for his own life, lest thereby the inheritance of the issue and reversion of the donor might have been defeated. 3. To empower him to charge the land with rents, commons, and certain other encumbrances, so as to bind his issue. And this was thought the more reasonable, because, by the birth of issue, the possibility of the donor's reversion was rendered more distant and precarious: and his interest seems to have been the only one which the law, as it then stood, was solicitous to protect, without much regard to the right of succession intended to be vested in the issue. However, if the tenant did not in fact alienate the land, the course of descent was not altered by this performance of the condition: for if the issue had afterwards died, and then the tenant or original grantee had died, without making any alienation, the land, by the terms of the donation, could descend to none but the heirs of his body; and therefore, in default of them, must have reverted to the donor. For which reason, in order to subject the lands to the ordinary course of descent, the donees of these conditional fee-simples took care to alienate as soon as they had performed the condition by having issue; and afterwards repurchased the lands, which gave them a fee-simple absolute, that would descend to the heirs general, according to the course of the common law. And thus stood the old law with regard to conditional fees: which things, says Sir Edward Coke, though they seem ancient, are yet necessary to be known, as well for the declaring how the common law stood in such cases, as for the sake of annuities, and such-like inheritances, as are not within the statutes of entail, and therefore remain as the common law. The inconveniences which attended these limited and fettered inheritances were probably what induced the judges to give way to this subtle finess (for such it undoubtedly was), in order to shorten the duration of these conditional estates. But, on the other hand, the nobility, who were willing to perpetuate their

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possessions in their own families, to put a stop to this practice, procured the statute of Westminster the second (commonly called the statute *de donis conditionalibus*) to be made; which paid a greater regard to the private will and intentions of the donor, than to the propriety of such intentions, or any public considerations whatsoever. This statute revived in some sort the ancient feudal restraints which were originally laid on alienations, by enacting, that from thenceforth the will of the donor be observed; and that the tenements so given (to a man and the heirs of his body) should at all events go to the issue, if there were any; or if none, should revert to the donor.

Upon the construction of this act of parliament, the judges determined that the donee had no longer a conditional fee simple, which became absolute and at his own disposal the instant any issue was born; but they divided the estate into two parts, leaving in the donee a new kind of particular estate, which they denominated a *fee-tail*; and vesting in the donor the ultimate fee-simple of the land, expectant on the failure of issue; which expectant estate is what we now call a *reversion*. And hence it is that Littleton tells us, that tenant in fee-tail is by virtue of the statute of Westminster the second. The expression *fee-tail*, or *feodum talliatum*, was borrowed from the feudists (see Crag. l. s. t. 10. § 24, 25.), among whom it signified any mutilated or truncated inheritance, from which the heirs-general were cut off; being derived from the barbarous verb *taliare*, to cut; from which the French *tailleur* and the Italian *tagliare* are formed, (Spelm. *Gloss.* 531.).

Having thus shown the original of estates tail, we now proceed to consider what things may or may not be entailed under the statute *de donis*. Tenements is the only word used in the statute: and this Sir Edward Coke expounds to comprehend all corporeal hereditaments whatsoever; and also all incorporeal hereditaments which favour of the realty, that is, which issue out of corporeal ones, or which concern or are annexed to or may be exercised within the same; as rents, estovers, commons, and the like. Also offices and dignities, which concern lands, or have relation to fixed and certain places, may be entailed. But mere personal chattels, which favour not at all of the realty, cannot be entailed. Neither can an office, which merely relates to such personal chattels; nor an annuity, which charges only the person, and not the lands of the grantor. But in these last, if granted to a man and the heirs of his body, the grantee hath still a fee conditional at common law as before the statute, and by his alienation may bar the heir or reversioner. An estate to a man and his heirs for another's life cannot be entailed; for this is strictly no estate of inheritance, and therefore not within the statute *de donis*. Neither can a copyhold estate be entailed by virtue of the statute; for that would tend to encroach upon and restrain the will of the lord: but, by the special custom of the manor, a copyhold may be limited to the heirs of the body; for here the custom ascertains and interprets the lord's will.

As to the several species of estates tail, and how they are respectively created; they are either general or special. Tail-general is where lands and tenements are given to one, and the heirs of his body begotten: which is called *tail-general*; because, how often soever such donee in tail be married, his issue in general, by all and every such marriage, is, in successive order, capable of inheriting the estate-tail *per formam doni*. Tenant in *tail-special* is where the gift is restrained to certain heirs of the donee's body, and does not go to all of them in general. And this may happen several ways. We shall instance in only one; as where lands and tenements are given to a man and the heirs of his body, on Mary his now wife to be begotten. Here no issue can in-

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herit but such special issue as is engendered between them two; not such as the husband may have by another wife; and therefore it is called *special tail*. And here we may observe, that the words of inheritance (to him and his heirs) give him an estate in fee; but they being heirs to be by him begotten, this makes it a fee-tail; and the person being also limited, on whom such heirs shall be begotten (viz. Mary his present wife), this makes it a fee-tail special.

Estates in general and special tail are farther diversified by the distinction of sexes in such entails; for both of them may either be in tail male or tail female. As if lands be given to a man, and his heirs-male of his body begotten, this is an estate in tail male general; but if to a man, and the heirs-female of his body on his present wife begotten, this is an estate in tail female special. And in case of an entail male, the heirs-female shall never inherit, nor any derived from them; nor, *e converso*, the heirs-male in case of a gift in tail female. Thus, if the donee in tail male hath a daughter, who dies leaving a son, such grandson in this case cannot inherit the estate-tail; for he cannot deduce his descent wholly by heirs-male. And as the heir-male must convey his descent wholly by males, so must the heir-female wholly by females. And therefore if a man hath two estates-tail, the one in tail male and the other in tail female, and he hath issue a daughter, which daughter hath issue a son; this grandson can succeed to neither of the estates, for he cannot convey his descent wholly either in the male or female line.

As the word *heirs* is necessary to create a fee, so, in farther imitation of the strictness of the feudal donation, the word *body*, or some other words of procreation, are necessary to make it a fee-tail, and ascertain to what heirs in particular the fee is limited. If, therefore, either the words of inheritance or words of procreation be omitted, albeit the others are inserted in the grant, this will not make an estate-tail. As if the grant be to a man and the issue of his body, to a man and his seed, to a man and his children or offspring; all these are only estates for life, there wanting the words of inheritance, "his heirs." So, on the other hand, a gift to a man, and his heirs male or female, is an estate in fee-simple and not in fee-tail; for there are no words to ascertain the body out of which they shall issue. Indeed, in last wills and testaments, wherein greater indulgence is allowed, an estate-tail may be created by a devise to a man and his seed, or to a man and his heirs-male, or by other irregular modes of expression.

There is still another species of entailed estates, now indeed grown out of use, yet still capable of subsisting in law; which are estates in *libero maritagio*, or FRANKMARRIAGE. See that article.

The incidents to a tenancy in tail, under the statute Westminster 2. are chiefly these: 1. That a tenant in tail may commit waste on the estate tail, by selling timber, pulling down houses, or the like, without being impeached or called to account for the same. 2. That the wife of the tenant in tail shall have her dower, or thirds, of the estate-tail. 3. That the husband of a female tenant in tail may be tenant by the curtesy of the estate-tail. 4. That an estate-tail may be barred, or destroyed, by a fine, by a common recovery, or by lineal warranty descending with assets to the heir. See ASSETS.

Thus much for the nature of estates-tail: the establishment of which family-law (as it is properly styled by Pigott) occasioned infinite difficulties and disputes. Children grew disobedient when they knew they could not be set aside: farmers were ousted of their leases made by tenants in tail; for if such leases had been valid, then, under colour of long leases, the issue might have been virtually disinherited: creditors were defrauded of their debts; for, if

Tail. a tenant in tail could have charged his estate with their payment, he might also have defeated his issue, by mortgaging it for as much as it was worth: innumerable latent entails were produced to deprive purchasers of the lands they had fairly bought; of suits in consequence of which, our ancient books are full: and treasons were encouraged, as estates-tail were not liable to forfeiture longer than for the tenant's life. So that they were justly branded as the source of new contentions and mischiefs unknown to the common law; and almost universally considered as the common grievance of the realm. But as the nobility were always fond of this statute, because it preserved their family-estates from forfeiture, there was little hope of procuring a repeal by the legislature; and therefore, by the connivance of an active and politic prince, a method was devised to evade it.

About 200 years intervened between the making of the statute *de donis*, and the application of common recoveries to this intent, in the 12th year of Edward IV.; which were then openly declared by the judges to be a sufficient bar of an estate-tail. For though the courts had, so long before as the reign of Edward III. very frequently hinted their opinion that a bar might be effected upon these principles, yet it was never carried into execution; till Edward IV. observing (in the disputes between the houses of York and Lancaster) how little effect attainders for treason had on families whose estates were protected by the sanctuary of entails, gave his countenance to this proceeding, and suffered Taltarum's case to be brought before the court: wherein, in consequence of the principles then laid down, it was in effect determined, that a common recovery suffered by tenant in tail should be an effectual destruction thereof. These common recoveries are fictitious proceedings, introduced by a kind of *pia fraud*, to elude the statute *de donis*, which was found so intolerably mischievous, and which yet one branch of the legislature would not then consent to repeal: and that these recoveries, however clandestinely begun, are now become by long use and acquiescence a most common assurance of lands; and are looked upon as the legal mode of conveyance, by which a tenant in tail may dispose of his lands and tenements: so that no court will suffer them to be shaken or reflected on, and even acts of parliament have by a side-wind countenanced and established them.

This expedient having greatly abridged estates-tail with regard to their duration, others were soon invented to strip them of other privileges. The next that was attacked was their freedom from forfeitures for treason. For, notwithstanding the large advances made by recoveries, in the compass of about three score years, towards unfettering these inheritances, and thereby subjecting the lands to forfeiture, the rapacious prince then reigning, finding them frequently resettled in a similar manner to suit the convenience of families, had address enough to procure a statute, whereby all estates of inheritance (under which general words estates-tail were covertly included) are declared to be forfeited to the king upon any conviction of high-treason.

The next attack which they suffered, in order of time, was by the statute 32 Hen. VIII. c. 28. whereby certain leases made by tenants in tail, which do not tend to the prejudice of the issue, were allowed to be good in law, and to bind the issue in tail. But they received a more violent blow in the same session of parliament, by the construction put upon the statute of fines, by the statute 32 Hen. VIII. c. 36. which declares a fine duly levied by tenant in tail to be a complete bar to him and his heirs, and all other persons claiming under such entail. This was evidently agreeable to the intention of Henry VII. whose policy it was (before common recoveries had obtained their full strength and authority) to lay the road as open as possible to the aliena-

tion of landed property, in order to weaken the overgrown power of his nobles. But as they, from the opposite reasons, were not easily brought to consent to such a provision, it was therefore couched, in his act, under covert and obscure expressions. And the judges, though willing to construe that statute as favourably as possible for the defeating of entailed estates, yet hesitated at giving fines so extensive a power by mere implication, when the statute *de donis* had expressly declared that they should not be a bar to estates-tail. But the statute of Henry VIII. when the doctrine of alienation was better received, and the will of the prince more implicitly obeyed than before, avowed and established that intention. Yet, in order to preserve the property of the crown from any danger of infringement, all estates-tail created by the crown, and of which the crown has the reversion, are excepted out of this statute. And the same was done with regard to common recoveries, by the statute 34 and 35 Hen. VIII. c. 20. which enacts, that no feigned recovery had against tenants in tail, where the estate was created by the crown, and the remainder or reversion continues still in the crown, shall be of any force and effect. Which is allowing, indirectly and collaterally, their full force and effect with respect to ordinary estates tail, where the royal prerogative is not concerned.

Lastly, by a statute of the succeeding year, all estates-tail are rendered liable to be charged for payment of debts due to the king by record or special contract; as since, by the bankrupt-laws, they are also subjected to be sold for the debts contracted by a bankrupt. And, by the construction put on the statute 43 Eliz. c. 4. an appointment by tenant in tail of the lands entailed to a charitable use is good without fine or recovery.

Estates-tail being thus by degrees unfettered, are now reduced again to almost the same state, even before issue-born, as conditional fees were in at common law, after the condition was performed by the birth of issue. For, first, the tenant in tail is now enabled to alienate his lands and tenements by fine, by recovery, or by certain other means; and thereby to defeat the interest as well of his own issue, though unborn, as also of the reversioner, except in the case of the crown: secondly, he is now liable to forfeit them for high treason: and, lastly, he may charge them with reasonable leases, and also with such of his debts as are due to the crown on specialties, or have been contracted with his fellow-subjects in a course of extensive commerce.

TAILZIE, in Scots law, the same with **TAIL**. See **LAW**, No clxxx. 9.

TALAPOINS or **TALOPINS**, priests of Siam.—They enjoy great privileges, but are enjoined celibacy and austerity of life. They live in monasteries contiguous to the temples: and what is singular, any one may enter into the priesthood, and after a certain age may quit it to marry, and return to society. There are talapoinesses too, or nuns, who live in the same convents, but are not admitted till they have passed their fortieth year. The talapoins educate children; and at every new and full moon explain the precepts of their religion in their temples; and during the rainy season they preach from six in the morning till noon, and from one in the afternoon till five in the evening. They dress in a very mean garb, go bareheaded and barefooted; and no person is admitted among them who is not well skilled in the Baly language.

They believe that the universe is eternal; but admit that certain parts of it, as this world, may be destroyed and again regenerated. They believe in a universal pervading spirit, and in the immortality and transmigration of the soul; but they extend this last doctrine, not only to all animals, but to vegetables and rocks. They have their good and evil

Tail
||
Talapoins.

Talc. evil geni, and particular local deities, who preside over forests and rivers, and interfere in all sublunary affairs.

For the honour of human nature, we are happy to find so pure a system of morality prevail among these people: It not only forbids its followers to do ill, but enjoins the necessity of doing good, and of stifling every improper thought or criminal desire.

Those who wish to peruse a more particular account of the talapoins, may consult *Voyage de M. de la Loubere*; Sketches relating to the History, &c. of the Hindoos; or Payne's Geography.

TALC, in mineralogy, a species of fossil arranged under the magnesian earths. In Magellan's edition of Cronstedt's Mineralogy, it is considered as a species of MICA, and has accordingly been mentioned by us under that article. On the other hand, Dr Kirwan has classed the mica under the siliceous earths, while he places talc under the magnesian. According to the analysis of Dr Kirwan, "talc consists of pure magnesia, mixed with nearly twice its weight of silica, and less than its own weight of argil." It is composed of broad, flat, and smooth lamina, or plates. There are two varieties of it, the Venetian talc and Muscovy talc; for the difference of which, see the article MICA.

The Venetian talc has not derived its name from being a production of the territories of Venice (for it is not often to be met with in that country), but probably from being an article of Venetian commerce. It abounds in England, Norway, Hungary, Bohemia, Spain, and in many countries of Asia. Venice talc, with half its weight of alkaline salt, may, in a strong fire, be brought into perfect fusion, though not to perfect transparency: with equal its weight, or less, of borax, it runs into a beautiful, pellucid, greenish yellow glass. Talc does not melt with any other earth, nor even bake or cohere with any but the argillaceous: Mixtures of it with them all are nevertheless brought into fusion by a remarkably less quantity of saline matter than the ingredients separately would require. Thus equal parts of talc and chalk, with only one-fourth their weight of borax, melt in no very vehement heat into a fine transparent greenish glass, of considerable hardness and great lustre. On substituting gypseous earths to chalk, the fusion was as easy, and the glass as beautiful; in colour not green, but yellow like the topaz. Talc, with half its weight of sand, and a quantity of nitre equal to both, yielded also a transparent topaz yellow glass. Several further experiments on talc may be seen in a memoir by Mr Pott in the *Mem. de l'Acad. de Berlin*, 1746.

Muscovy talc, called also *lapis specularis*, is found in many parts. The island of Cyprus abounds with it. It is very common also in Russia, and has of late been discovered to abound in the Alps, the Apennines, and many of the mountains of Germany. It is imported in large quantities into England, and is used by the lanthorn-makers instead of horn in their nicer works; by the painters to cover miniature pictures; and by the microscope-makers to preserve small objects for viewing by glasses. The ancients used it instead of glass in their windows. Some take the lapis specularis to have been a species of gypsum, and composed of the acid of vitriol and calcareous earth. It came into use at Rome in the age of Seneca*; and soon after its introduction was applied not only to lighten apartments, but to protect fruit-trees from the severity of the weather; and it is recorded, that the emperor Tiberius was enabled, principally by its means, to have cucumbers at his table during almost every month in the year. Dr Watson apprehends it is still used in some countries in the place of glass: however, it is well known, that it was so used in the time of Agricola; for he mentions† two churches in Saxony which were lighted by it.

Agricola esteemed it to have been a species of plaster-stone; and in speaking of it he remarks, that though it could bear, without being injured, the heat of summer and the cold of winter, yet the largest masses of it were wasted by the rain. It differs from plaster-stone in this property, that it does not, after being calcined and wetted with water, swell and concrete into a hard stony substance*.

Although we have treated of Muscovy talc and lapis specularis as the same, we are not ignorant that a distinction has been made between them by some chemists: but as we have found a greater degree of confusion on this subject in several valuable systems of mineralogy than we had reason to expect, we continue the old names as formerly, till a more satisfactory analysis make it proper to apply them differently.

Talc is employed, in those places where it is found in any considerable quantity, in compositions for earthen vessels; and by some for tests and cupels. From its smoothness, unctuousity, and brightness, it has been greatly celebrated as a cosmetic; and the chemists have submitted it to a variety of operations, for procuring from it oils, salts, tinctures, magisteries, &c. for that intention. But all their labours have been in vain; and all the preparations sold under the name of talc have either contained nothing of that mineral, or only a fine powder of it.

TALENT, signifies both a weight and a coin very common among the ancients, but very different among different nations.

The common Attic talent of weight contains 60 Attic minæ, or 6000 Attic drachmæ; and weighed, according to Dr Arbuthnot, 56 lbs. 11 oz. 17½ gr. English troy weight. There was another Attic talent, by some said to consist of 80, by others of 100 minæ. The Egyptian talent was 80 minæ; the Antiochian also 80; the Ptolemaic of Cleopatra 86½; that of Alexandria 96; and the Insular talent 120. In the valuation of money, the Grecian talent, according to Dr Arbuthnot, was equal to 60 minæ, or, reckoning the mina at L. 3 : 4 : 7, equal to L. 193, 15s: The Syrian talent in this valuation consisted of 15 Attic minæ; the Ptolemaic of 20; the Antiochian of 60; the Euboic of 60; the Babylonian of 70; the Greater Attic of 80; the Tyrian of 80; the Egeian of 100; the Rhodian of 100; and the Egyptian of 80 minæ.

There is another talent much more ancient, which Dr Arbuthnot calls the *Homerian talent* of gold, which seems to have weighed six Attic drachms or three darics, a daric weighing very little more than a guinea. According to this talent, some reckon the treasure of king David, particularly that mentioned 1 Chron. xxii. 14. which, according to the common reckoning, would amount in gold talents to the value of L. 547,500,000, and the silver to above L. 342,000,000; or, reckoning according to the decuple proportion of gold to silver, the two sums would be equal. As David reigned in Judæa after the siege of Troy, it is not improbable but Homer and he might use the same numeral talent of gold.

Among the Romans there were two kinds of talents, the *little* and the *great* talent: the little was the common talent; and whenever they say simply *talentum*, they are to be understood of this. The little talent was 60 minæ or Roman pounds; the mina or pound estimated at 100 drachmæ or denarii: it was also estimated at 24 great sesterces, which amounted to 60 pounds.

The great talent exceeded the less by one-third part. Budæus computes, that the little talent of silver was worth L. 75 Sterling, and the greater L. 99 : 6 : 8 Sterling. The greater of gold was worth L. 1125 Sterling.

TALENT, as a species or money, among the Hebrews, was

Hist. Hist.
of Foss.
p. 72.

* Ep. 90.

* De Nat.
Foss. lib. 5.
p. 257.

* Watson's
Chem. Ess.
vol. ii.
p. 297, &c.

Taliacotius was sometimes used for a gold coin, the same with the shekel of gold, called also *flater*, and weighing only 4 drachms. The Hebrews reckoned by these talents as we do by pounds, &c. Thus a million of gold, or million of talents of gold, among them, was a million of shekels or nummi; the nummus of gold being the same weight with the shekel, viz. four drachms.

But the Hebrew talent weight of silver, which they called *cicar*, was equivalent to that of 3000 shekels, or 113 lb. 10 oz. 1 dwt. 10 $\frac{1}{2}$ gr. English Troy weight, according to Arbuthnot's computation.

TALIACOTIUS (Gaspar), chief surgeon to the great duke of Tuscany, was born at Bononia in Italy in 1553. He wrote a Latin treatise intitled *Chirurgia Nota de Curtis Membris*, in which he teaches the art of engrafting noses, ears, lips, &c. giving representations of the instruments and proper bandages; though many are of opinion that he never put his art in practice. However, his doctrine is not singular; for he shows that Alexander Benedictus, a famous surgical writer, described the operation before.

TALLIO (*lex talionis*), a species of punishment in the Mosaic law, whereby an evil is returned similar to that committed against us by another; hence that expression, "Eye for eye, tooth for tooth." This law was at first inserted in the 12 tables amongst the Romans; but afterwards set aside, and a power given to the prætor to fix upon a sum of money for the damage done.

TALISMANS, magical figures cut or engraved with superstitious observations on the characterisms and configurations of the heavens, to which some astrologers have attributed wonderful virtues, particularly that of calling down celestial influences. The talismans of Samothrace, so famous of old, were pieces of iron formed into certain images, and set in rings; these were esteemed preservatives against all kinds of evils. There were likewise talismans taken from vegetables, and others from minerals.

TALLAGE (*tallagium*), from the French *taille*, is metaphorically used for a part or share of a man's substance carved out of the whole, paid by way of tribute, toll, or tax.

TALLOW, in commerce, the fat of certain animals melted and clarified. It is procured from most animals, but chiefly from bullocks, sheep, hogs, and bears. Some kinds of tallow are used as unguents in medicine, some for making soap and dressing leather, and some for making candles. See **CHEMISTRY**, n° 1429.

TALLOW Tree. See **CROTON**.

TALLY, is a stick cut in two parts, on each whereof is marked, with notches or otherwise, what is due between debtor and creditor, as now used by brewers, &c. And this was the ancient way of keeping all accounts, one part being kept by the creditor, the other by the debtor, &c. Hence the tallier of the exchequer, whom we now call the *teller*. But there are two kinds of tallies mentioned in our statutes to have been long used in the exchequer. The one is termed *tallies of debt*, which are in the nature of an acquittance for debts paid to the king, on the payment whereof these tallies are delivered to the debtors, who carrying them to the clerk of the pipe-office, have there an acquittance in parchment for their full discharge. The other are *tallies of reward* or allowance, being made to sheriffs of counties as a recompense for such matters as they have performed to their charge, or such money as is cast upon them in their accounts of course, but not leviable, &c. In the exchequer there is a tally-court, where attend the two deputy-chamberlains of the exchequer and the tally-cutter: and a tally is generally the king's acquittance for money paid or lent, and has written on it words proper to express on what occasion the money is received.

TALLY-Man, a person that sells or lets goods, clothes, &c. to be paid by so much a-week. Talmud.

TALMUD, a collection of Jewish traditions. There are two works which bear this name, the Talmud of Jerusalem, and the Talmud of Babylon. Each of these are composed of two parts; the Mishna, which is the text, and is common to both, and the Gemara or commentary. See **MISHNA** and **GEMARA**.

The Mishna, which comprehends all the laws, institutions, and rules of life which, beside the ancient Hebrew scriptures, the Jews thought themselves bound to observe, was composed, according to the unanimous testimony of the Jews, about the close of the second century. It was the work of Rabbi Jehuda (or Juda) Hakkadosh, who was the ornament of the school at Tiberias, and is said to have occupied him forty years. The commentaries and additions which succeeding Rabbis made were collected by Rabbi Johanan Ben Eliezer, some say in the 5th, others say in the 6th, and others in the 7th century, under the name of *Gemara*, that is, *completion*; because it completed the Talmud. A similar addition was made to the Mishna by the Babylonish doctors in the beginning of the 6th century according to Enfield, and in the 7th according to others.

The Mishna is divided into six parts, of which every one which is intitled *order* is formed of treatises, every treatise is divided into chapters, and every chapter into mishnas or aphorisms. In the *first* part is discussed whatever relates to seeds, fruits, and trees: in the *second* feasts: in the *third* women, their duties, their disorders, marriages, divorces, contracts, and nuptials: in the *fourth* are treated the damages or losses sustained by beasts or men, of things found, deposits, usuries, rents, farms, partnerships in commerce, inheritance, sales and purchases, oaths, witnesses, arrests, idolatry; and here are named those by whom the oral law was received and preserved: in the *fifth* part are noticed what regards sacrifices and holy things: and the *sixth* treats on purifications, vessels, furniture, clothes, houses, leprosy, baths, and numerous other articles. All this forms the Mishna.

As the learned reader may wish to obtain some notion of rabbinical composition and judgment, we shall gratify his curiosity sufficiently by the following specimen: "Adam's body was made of the earth of Babylon, his head of the land of Israel, his other members of other parts of the world. R. Meir thought he was compact of the earth gathered out of the whole earth; as it is written, *thine eyes did see my substance*. Now it is elsewhere written, *the eyes of the Lord are over all the earth*. R. Aha expressly marks the twelve hours in which his various parts were formed. His stature was from one end of the world to the other; and it was for his transgression that the Creator, laying his hand in anger on him, lessened him; for before (says R. Eleazar), 'with his hand he reached the firmament.' R. Jehuda thinks his sin was heresy; but R. Isaac thinks that 'it was nourishing his foreskin.'"

The Talmud of Babylon is most valued by the Jews; and this is the book which they mean to express when they talk of the Talmud in general. An abridgment of it was made by Maimonides in the 12th century, in which he rejected some of its greatest absurdities. The Gemara is stuffed with dreams and chimeras, with many ignorant and impertinent questions, and the style very coarse. The Mishna is written in a style comparatively pure, and may be very useful in explaining passages of the New Testament where the phraseology is similar. This is indeed the only use to which Christians can apply it; but this renders it valuable. Lightfoot has judiciously availed himself of such information as he could derive from it. Some of the popes, with a barbarous

Talpa
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Tamarin-
dus.

barous zeal, and a timidity of spirit for the success of the Christian religion, which the belief of its divinity can never excuse, ordered great numbers of the Talmud to be burned. Gregory IX. burned about 20 cart-loads, and Paul IV. ordered 12,000 copies of the Talmud to be destroyed.

The last edition of the Talmud of Babylon, printed at Amsterdam, is in 12 vols folio. The Talmud of Jerusalem is in one large folio.

TALPA, the MOLE; a genus of quadrupeds belonging to the order of *feræ* and class of *mammalia*. It has six unequal foreteeth in the upper jaw, and eight in the lower; one tusk on each side in each jaw; seven grinders on each side above, and six below. There are seven species; the European, the flava or American, the cristata, longicaudata, fusca, rubra, and aurea.

The European mole is the only species of this animal found in Britain. There are several varieties of it; the black, the variegated, the white, and the grey mole. This species inhabits the whole of Europe except Ireland, where it is said no moles are found. It is also common in the northerly parts of Asia and Africa. It chiefly frequents moist fields that are exposed to the sun, meadows, and gardens; through these it constructs subterraneous roads or galleries in every direction in search of worms, on which and the larvæ of insects it feeds, and not at all on vegetables, though it does great damage by loosening the roots of plants. It is most active in its operations before rain, because then the worms are in motion. The penis of the male is exceedingly long in proportion; they seem to pair and propagate in spring, the female bringing four or five young at a birth, which are placed in nests made of moss, leaves, and dried grass, under the largest hillocks of the field; these are constructed with wonderful ingenuity, consisting of an interior hillock, surrounded with a ditch, which communicates with several galleries, on purpose to carry off the moisture; and the nest is covered over with a dome of earth, like the flat arch of an oven. Moles are destroyed by means of a paste composed of palma-christi and white hellebore, or by flooding the fields which they infest; though, in the latter case, they sometimes escape by ascending trees.

This species is five inches and three quarters in length, and its tail is about one inch long. It has a large head, without any external ears, and eyes so very small and so completely hid in the fur as to make it vulgarly believed that it has none. As it lives entirely below ground, it has certainly no occasion for eyes like other quadrupeds; and as it probably finds its food by its sense of smell, which is acute, its eyes may serve merely as a safeguard to warn it when it happens to emerge from the ground to return to its subterraneous dwelling. This warning may be given by the light falling upon its eyes, which may produce a painful sensation. For the truth of this conjecture, however, we must refer to the anatomist, who might easily determine, from the structure of the eyes, what purpose they are fitted to serve.

TAMANDAU, in zoology. See MYRMECOPHAGA.

TAMARINDUS, the TAMARIND-TREE, in botany: A genus of plants arranged by Linnæus under the class of *triandria* and order of *monogynia*; but Woodville, Schreber, and other late botanists, have found that it belongs to the class of *monodelphia* and order of *triandria*. In the natural

system it is ranked under the *lomentacea*. There is only one species, the *indica*, which is a native of both Indies, of America, of Arabia, and Egypt, and was cultivated in Britain before the year 1633.

The tamarind-tree rises to the height of 30 or 40 feet, sending off numerous large branches, which spread to a considerable extent, and have a beautiful appearance; the trunk is erect, and covered with rough bark, of a greyish or ash-colour; the leaves are small and pinnated, and of a yellowish green colour: the flowers resemble the papilionaceous kind, and grow in lateral clusters: the calyx consists of four leaves, and the corolla of three petals, which are of a yellowish hue, and are beautifully diversified with red veins: the fruit is a pod of a roundish compressed form, from three to five inches long, containing two, three, or four seeds, lodged in a dark pulpy matter. The flowers appear, according to Jacquin, in October and November; but, according to Dr Wright, they continue during the whole of June and July, and then drop off.

The pulp of the tamarind, with the seeds connected together by numerous tough strings or fibres, are brought to us freed from the outer shell, and commonly preserved in syrup. According to Long, tamarinds are prepared for exportation at Jamaica in the following manner: "The fruit or pods are gathered (in June, July, and August) when full ripe, which is known by their fragility or easy breaking on small pressure between the finger and thumb. The fruit, taken out of the pod, and cleared from the shelly fragments, is placed in layers in a cask; and boiling syrup, just before it begins to granulate, is poured in, till the cask is filled: the syrup pervades every part quite down to the bottom, and when cool the cask is headed for sale." He observes, that the better mode of preserving this fruit is with sugar, well clarified with eggs, till a transparent syrup is formed, which gives the fruit a much pleasanter flavour: but as a principal medicinal purpose of the pulp depends upon its acidity, which is thus counteracted by the admixture of sugar, it would therefore be of more utility if always imported here in the pods. The fruit produced in the East Indies is more esteemed than that of the West, and easily to be distinguished by the greater length of the pods, and the pulp being dryer and of a darker colour.

Uses. This fruit, the use of which was first learned of the Arabians, contains a larger proportion of acid, with the saccharine matter, than is usually found in the *fructus acidodulcis*, and is therefore not only employed as a laxative, but also for abating thirst and heat in various inflammatory complaints, and for correcting putrid disorders, especially those of a bilious kind; in which the cathartic, antiseptic, and refrigerant qualities of the fruit have been found equally useful. When intended merely as a laxative, it may be of advantage to join it with manna, or purgatives of a sweet kind, by which its use is rendered safer and more effectual. Three drachms of the pulp are usually sufficient to open the body; but to prove moderately cathartic, one or two ounces are required. It is an ingredient in *electuarium e cassia*, and *electuarium e senna* or lenitive electuary (A).

We are informed by Dr Wright, that preserved tamarinds are kept in most houses in Jamaica either as a sweet-meat, or for occasional use as a medicine. See PHARMACY, n° 394 and 395.

TAMARIX,

(A) "Tournefort relates, that an essential salt may be obtained from tamarinds, by dissolving the pulp in water, and setting the filtered solution, with some oil upon the surface, in a cellar for several months; that the salt is of a sourish taste, and difficultly dissoluble in water; and that a like salt is sometimes found also naturally concentered on the branches of the tree. The salt, as Beaumé observes, may be obtained more expeditiously, by clarifying the decoction of the tamarinds

Tamarix

Tamerlane.

TAMARIX, the **TAMARISK**, in botany: A genus of plants belonging to the class of *pentandria*, and order of *trigynia*; and in the natural system ranging under the 13th order, *Succulentæ*. The calyx is quinquepartite; the petals are five; the capsule is unilocular and trivalvular, and the seeds pappous. There are only two species known; the *gallica*, or French tamarisk, and the *germanica* or German tamarisk.

TAMBAC, in the *materia medica*. See **EXCÆCANA**.

TAMBOUR, in architecture, a term applied to the Corinthian and Composite capitals, as bearing some resemblance to a drum which the French call *tambour*. Some choose to call it the *vase*, and others *campana* or the bell.

TAMBOUR is also used for a little box of timber work, covered with a ceiling, within the porch of certain churches; both to prevent the view of persons passing by, and to keep off the wind, &c. by means of folding doors, &c.

TAMBOUR, also denotes a round course of stone, several whereof form the shaft of a column, not so high as a diameter.

TAMBOUR, in the arts, is a species of embroidery. The *tambour* is an instrument of a spherical form, upon which is stretched, by means of a string and buckle, or other suitable appendage, a piece of linen or thin silken stuff; which is wrought with a needle of a particular form, and by means of silken or gold and silver threads, into leaves, flowers, or other figures.

TAMBOURIN, is the name of a dance performed on the French stage. The air is lively, and the movements are quick.

TAMERLANE, or **TIMUR BEK**, a celebrated prince and conqueror. At the age of 25 he attained the highest dignities, with surprising courage, and an ambition astonishing to all the world. Endeavouring to perfect the great talents which he had received from nature, he spent nine years in different countries; where his great sense and elevated genius appeared in councils and assemblies, while his intrepidity and valour, whether in personal combats or pitched battles, drew upon him the admiration of all mankind. He made himself master of the three empires of Jagatay Khân, Tufhi Khân, and Hülakû Khân; so that his power, riches, and magnificence, were immense. There remain vast monuments of his grandeur in the cities, towns, castles, and walls, which he built; in the rivers and canals which he dug, as well as the bridges, gardens, palaces, hospitals, mosques, and monasteries, which he erected in divers parts of Asia in so great a number, that a king might be accounted very powerful and magnificent, who should have employed 36 years only in building the great edifices which Timûr caused to be founded.

Timûr, according to the historian Arabshâh, was in his person very corpulent and tall. He had a large forehead and big head. His countenance was agreeable, and his complexion fair. He wore a large beard, was very strong, and well-limbed; had broad shoulders, thick fingers, and long legs. His constitution was amazingly vigorous; but he was maimed in one hand and lame of the right side. His eyes appeared full of fire; his voice was loud and piercing; he feared nothing; and when far advanced in years, his understanding was sound and perfect, his body vigorous and robust, his mind constant and unshaken like a rock.

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He did not like raillery, and could not bear a lie. There was no joking or fooling before him; for he loved the naked truth, even although it was to his own disadvantage. He neither grieved if he miscarried in any attempt, nor appeared overjoyed on any great success. The device of his seal was, "I am sincere and plain." He had a clear and solid understanding, was surprisingly happy in his conjectures; vigilant, active, and unshaken in his resolutions. He took great delight in reading history, and was well versed in the state of countries, provinces, and cities. He was penetrating, subtle, close, and dissembling; just by inclination, liberal from disposition; but ambition had in a great measure extinguished his humanity; war had familiarized him to blood; and his religious zeal had inspired him with the most cruel, implacable, and pernicious fanaticism.

He died on the 1st of April, 1405, in the 71st year of his age and 36th of his reign. When he found death approaching, he sent for his principal officers, declared his grandson his heir, and made them swear to execute his will. Having recommended brotherly love and concord to the princes his children, he ordered one of the doctors to read the Koran at his bed's head, and often repeat the unity of God. At night he several times made profession of his belief, "That there is no other God than God," and then expired. See **MOGULS**, n° 15, &c.

TAMTAM, a flat drum used by the Hindoos, resembling a tabor, but it is larger, and sounds louder.

TAMUS, **BLACK BRIONY**, in botany: A genus of plants belonging to the class of *diazia*, and order of *hexandria*; and in the natural system ranging under the 11th order, *Sarmen-tacea*. The male and female flowers are both sexpartite; there is no corolla; the style is trifid; the berry is trilocular and inferior, and contains two seeds. There are only two species known; the *elephantipes*, which is a native of the Cape of Good Hope, and we believe was first described by L'Heritier; and the *communis*.

The *communis*, or common black briony, is a native of England, but has not been observed growing wild in Scotland. It has a large root, which sends forth several long slender stems: the leaves are large, heart-shaped, dark green, and grow on long footstalks: the flowers are greenish, and the berry red. It flowers from May to August, and is frequent in hedges.

TAN, the bark of the oak after it has been ground and used by the tanner. The smaller sort is generally made up in little square cakes called *turf*, and sold for firing. The coarser sort is sometimes dried in the sun, and used by bakers for heating their ovens, &c. but its chief use is for making of hot-beds to raise pine-apples and other plants.—William III. introduced the use of it from Holland, for the purpose of raising orange trees; after which it was discontinued for many years: but about 1719, when *ananas* were first brought into England, it came into general use, and has ever since been in great estimation with gardeners for all the purposes of forcing, &c. on account of its strong and lasting fermentation. The smaller the tan the quicker it heats; but the larger sort acquires heat more gradually and retains it longer: the skilful gardener therefore uses the one or the other, or a mixture of both, according to the time and purpose for which it is wanted. It is some time after the tan comes out of the tanner's pit before it begins to heat, and therefore it is not fit for immediate use; but having

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rinds with whites of eggs, then filtering it, and evaporating it to a proper consistence, and setting it to cool: the salt shoots into crystals of a brown colour and very acid taste; but in dissolving and crystallizing them again, or barely washing them with water, they lose almost all their acidity, the acid principle of the tamarinds seeming not to be truly crystallizable." Vide *Lewis's Mat. Med.* p. 633.

Tank
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Tanning.

Tanning. scrubbed out or taken off; the hides are then put into a pit of strong liquor called *ooze* or *wooze*, prepared in pits called *letches* or *taps* kept for the purpose, by infusing ground bark in water; this is termed *colouring*; after which they are removed into another pit called a *scowering*, which consists of water strongly impregnated with vitriolic acid, or with a vegetable acid prepared from rye or barley. This operation (which is called *raising*), by distending the pores of the hides, occasions them more readily to imbibe the ooze, the effect of which is to astringe and condense the fibres, and give firmness to the leather. The hides are then taken out of the scowering, and spread smooth in a pit commonly filled with water, called a *binder*, with a quantity of ground bark strewed between each. After lying a month or six weeks, they are taken up; and the decayed bark and liquor being drawn out of the pit, it is filled again with strong ooze, when they are put in as before, with bark between each hide. They now lie two or three months, at the expiration of which the same operation is repeated; they then remain four or five months, when they again undergo the same process; and after being three months in the last pit, are completely tanned, unless the hides are so remarkably stout as to want an additional pit or layer.—The whole process requires from 11 to 18 months, and sometimes two years, according to the substance of the hide, and discretion of the tanner. When taken out of the pit to be dried, they are hung on poles; and after being compressed by a steel pin, and beat out smooth by wooden hammers called *beetles*, the operation is complete; and when thoroughly dry, they are fit for sale. Butts are chiefly used for the soles of stout shoes.

3
Hides.

The leather which goes under the denomination of *hides* is generally made from cow hides, or the lighter ox hides, which are thus managed. After the horns are taken off, and the hides washed, they are put into a pit of water saturated with lime, where they remain a few days, when they are taken out, and the hair scraped off on a wooden beam, as before described; they are then washed in a pit or pool of water, and the loose flesh, &c. being taken off, they are removed into a pit of weak ooze, where they are taken up and put down (which is technically termed *handling*) two or three times a-day for the first week: every second or third day they are shifted into a pit of fresh ooze, somewhat stronger than the former; till at the end of a month or six weeks they are put into a strong ooze, in which they are handled once or twice a-week with fresh bark for two or three months. They are then removed into another pit, called a *layer*, in which they are laid smooth, with bark ground very fine strewed between each hide. After remaining here two or three months, they are generally taken up, when the ooze is drawn out, and the hides put in again with fresh ooze and fresh bark; where, after lying two or three months more, they are completely tanned, except a few very stout hides, which may require an extra layer: they are then taken out, hung on poles, and being hammered and smoothed by a steel pin, are, when dry, fit for sale.

These hides are called *crop hides*; they are from 10 to 18 skins in tanning, and are used for the soles of shoes.

4
Skins.

Skins is the general term for the skins of calves, seals, hogs, dogs, &c. These, after being washed in water, are put into lime-pits, as before mentioned, where they are taken up and put down every third or fourth day, for a fortnight or three weeks, in order to dilate the pores and dissolve the gelatinous parts of the skin. The hair is then scraped off, and the flesh and excrescences being removed, they are put into a pit of water impregnated with pigeon-dung (called a *grainer* or *mastring*), forming a strong alkaline ley, which in a week or ten days soaking out the lime, grease, and sapo-

naceous matter (during which period they are several times scraped over with a crooked knife to work out the dirt and filth), softens the skins, and prepares them for the reception of the ooze. They are then put into a pit of weak ooze, in the same manner as the hides, and being frequently handled, are by degrees removed into a stronger and still stronger liquor, for a month or six weeks, when they are put into a very strong ooze, with fresh bark ground very fine, and at the end of two or three months, according to their substance, are sufficiently tanned; when they are taken out, hung on poles, dried, and fit for sale.

These skins are afterwards dressed and blacked by the currier; and are used for the upper-leathers of shoes, boots, &c.

The lighter sort of hides, called *dressing hides*, as well as horse-hides, are managed nearly in the same manner as skins; and are used for coach-work, harness-work, &c. &c.

As the method of tanning above described, and all others in general use, are extremely tedious and expensive in their operation, various schemes have at different times been suggested to shorten the process and lessen the expence.—Though most of these schemes have ultimately proved unsuccessful, yet it in a work of this kind it may be expected that we should not pass them over wholly unnoticed.

Some have imagined, and perhaps justly, that cold water alone is not an adequate menstruum for extracting the resinous qualities of bark, however assisted by the mucilage of the bark and of the skin; a decoction, instead of simple infusion, has therefore been recommended as a more effectual mode of obtaining those properties.

The late Dr Macbride of Dublin having been concerned in a leather manufactory, published in 1778 a new method of tanning. His projected improvements may be briefly classed under two heads: the one recommending the use of *vitriolic* instead of *vegetable* acid, brewed from rye or barley: the other substituting *lime-water*, for the purpose of extracting the virtues of the bark, instead of the *water* commonly used by tanners. With respect to the first, it is generally acknowledged that the vitriolic acid is very proper for raising or distending the pores of the hides intended for butts, as its operation is not only more simple and certain than the acid formerly used, but as it tends more effectually to render the texture of the leather firm and durable: it is therefore still preferred by the most skilful tanners. As to lime-water instead of water, it has been found inefficacious; and if the utmost care and attention be not observed, the leather is liable to suffer much injury. Even the shortening of the time and lessening of the expence (which were its chief recommendations) being very problematical, it is now almost generally exploded.

A very ingenious chemist has observed, that it is necessary, on account of a chemical combination between the astringent principle and the animal substance in the process of tanning, that free access should be given to the pure air; and therefore supposes that the process could not be conducted properly in close vessels *.

The methods of tanning in different provinces of France are so various, so complicated, and so contrary to the acknowledged principles of the manufacture, that it would be an endless and useless task to endeavour to detail them: we shall therefore content ourselves with a general reference to M. de la Lande's elaborate Treatise on this subject.

It has been said, that every part of the oak tree contains a great portion of astringent, gummy-resinous matter, and will therefore tan leather as effectually as the bark itself. This opinion, which was first published in 1674 by the Honourable Charles Howard (Phil. Trans. vol. ix.), has since been countenanced by the celebrated Buffon; who adds, that

Tanning.

5
Schemes to shorten the process and lessen the expence.

* Phil. Trans. vol. lxxiii. Barthelet.

Tanning. the bark of birch will answer the purpose of tanning even sole leather, which, it is well known, requires the strongest and most penetrating materials†.

† *Mem.
Acad. Sc.
Paris,
1786.*

A long memoir, written by M. Gleditsch, recommends the leaves, branches, fruit, and flowers, of a vast number of plants as substitutes for oak bark. Heath dried and pulverised, gall nuts, and the bark of birch, are said by M. Gefner to be used in different provinces of Germany. Abbé Nollet informs us, that the leaves of myrrh are used by the tanners in Naples. In Corsica they make use of the leaves of wild laurel dried in the sun and beaten into powder, and in the island of St Kilda they tan with the tormentil root. In some parts of Italy leather is tanned with myrtle leaves. In Russia, it is said, that leather is tanned with the bark of willow: and it may here be observed, that a late writer has recommended the extract of bark to be made in America, in order to lessen the expence of freight, &c. in conveying the bark itself to Europe.

In the year 1765, the Society of Arts, &c. granted a premium of L. 100 for the discovery of a method of tanning with oak saw-dust; which method has been adopted in Germany; and the Reverend Mr Swaine has lately revived the exploded substitute (mentioned by Gleditsch and others) of oak leaves.

The following proposal was communicated to the Bath Society for extracting the essence of oak bark:

Suppose (says the author) the operator has at hand a common family brew-house, with its necessary utensils; let him procure a ton of good oak bark ground as usual for the pit; and having placed a strainer to the mash-tub, fill it two-thirds with the bark; heat as much water, nearly boiling, as will sufficiently moisten it, and mash it well together. After it has stood about two hours, draw it off clear, and put it into a cask by itself. Make a second extract with a smaller quantity of boiling water than before, so as to draw off a quantity nearly equal to the first, and put that also into the same cask with the former.

These two extracts will probably contain in them as much of the virtues of the bark as the quantity of liquid will absorb.

A third extract, rather more in quantity than the other two, may be made from the same bark, and as soon as drawn off, should be returned into the copper again when empty, and employed for the first and second mash of a quantity of fresh bark, as the three extracts may be supposed to have carried off the virtues of the first. Then proceed as before till all the bark is steeped, and a strong liquid extract is drawn from it. The bark, when taken out of the copper, may be spread in the sun to dry, and serve as fuel in the succeeding operations.

The next process is, to evaporate the watery particles from the extract by a gentle heat, till it comes to the consistence of treacle. This may be done either by the air and heat of the sun, or by the still or iron pan over the fire.

Anthony Day, Esq; of London, obtained a patent, dated 17th July 1790, for a new method of tanning, "with half the bark in half the usual time." This plan chiefly consists in concentrating the bark into a strong extract, and in some mechanical improvements in the construction of the tan-yard. But neither the one nor the other have yet been adopted.

The 12th May 1795, a patent was granted to Mr Tucker of Wickham, Hants. He proposes that the vat, made of wood, be inclosed in a metallic coating or copper pit, completely soldered, to prevent the escape of any of the fluid. This is to be surrounded with a case of brick-work, leaving an interstice of a few inches; and a fire is to be made in a grate near the bottom of the pit, to keep the ooze mode-

ately warm, and thus to shorten the process. But the Tanning, great expence of these triple pits and of the fuel, it is to be Tantalus. feared, will counterbalance any advantages which might otherwise be derived from this invention.

Monsieur Seguin of Paris has lately submitted to the French Convention a new method of tanning, which is said to possess wonderful advantages. He has certainly exploded the ignorant and absurd systems of the French tanners, which we have above hinted at, and has shown much ingenuity and chemical knowledge in the prosecution of his discoveries; but his leading principles seem, in fact, to be nearly similar to those which have been long known and practised in England.

An ingenious manufacturer in London has, by the application of warm air, conveyed by means of flues from stoves properly constructed, and by other contrivances not generally known, considerably abridged the usual process of tanning. Some experiments have likewise been lately made with the bark of ash and of horse-chestnut.

A substitute for oak bark, the price of which has lately been enormous, is the grand desideratum in the manufacture of leather. Most of those above enumerated have hitherto been found ineffectual; but a patent, bearing date 16th January 1794, has been granted to Mr Ashton of Sheffield, Yorkshire, for his discovery of a cheap and expeditious method of tanning leather. This method chiefly consists in applying a preparation of mineral substances instead of oak bark. Those which, on account of their cheapness, are most to be preferred, are the dross of coal-pits, called *sulphur-stone* or *pyrites*, and the yellow ferruginous earth or red ochre; and, in general, all astringent, sulphureous, or vitriolated substances.

If this discovery, which is yet in its infancy, should prove successful, it may cause a material alteration in the process of this manufacture; and by reducing the expence, may ultimately be of great advantage to the public. Many other experiments are now making in England for the improvement of tanning; and as there are many persons of ingenuity and knowledge engaged in the leather manufacture, much may be expected from their industry and skill.

As the acts of Parliament respecting leather, &c. are very numerous, and many of them almost obsolete, we shall refer our readers to Burn's Justice, or to the Statutes at Large. We cannot, however, help remarking, that the act of James I. cap. 22. which prescribes the mode and manner in which leather shall be tanned, the materials to be used, and the time to be employed, is so palpably absurd and oppressive, that it ought to be immediately repealed.

The revenue arising from the duty on leather tanned in Great Britain (exclusive of oiled leather) is upwards of L. 200,000 per annum.

TANTALUS, in fabulous history, king of Phrygia and Paphlagonia, was the son of Jupiter and the nymph Plota. He one day entertained the gods at his table; when, to prove their divinity, he served up his son Pelops cut in pieces. All the deities, except Ceres, perceived his cruelty and impiety, and would not touch his provisions. That goddess, whose thoughts were solely employed about her daughter Proserpine, inadvertently eat a part of his left shoulder. Pelops, however, was restored to life; and an ivory shoulder given him in the room of that which had been eaten; while Tantalus was thrown into Tartarus, where he was punished with perpetual hunger and thirst. He was chained in a lake; the water of which reached up to his chin, but retired when he attempted to drink. The branch of a tree loaded with fruit hung down even to his lips, but on his attempting to pluck the fruit the branch sprung upwards.

Tantalus
||
Taormina.

TANTALUS, in ornithology, a genus of birds belonging to the order of grallæ. The bill is long, subulated, and somewhat crooked; the face naked; the tongue short; and the feet have four toes palmated on the under part. There are, according to Dr Latham, 23 species; of which the most remarkable is the *ibis*, the bird so much valued by the ancient Egyptians.

The ibis was formerly held in great veneration in Egypt, on account of its utility in freeing the country from serpents. Serpents must therefore have been numerous, or they could not have been very offensive; and the ibis must have been numerous, or they could not have been useful. Yet we are assured by Mr Bruce, that the ibis is at present unknown in Egypt, and serpents are no nuisance; and he thinks it impossible that a country, covered with water for five months of the year as Egypt is, could ever have abounded with serpents. He endeavours, however, to reconcile the accounts of ancient historians with the state of Egypt.

In former times, when Egypt was in its flourishing state, the inhabited country extended much farther than it does at present; reaching even a considerable way into the sandy desert of Libya, where serpents have their abode. These parts were supplied with water by immense lakes, dug by the magnificent princes of those times, and filled by the annual inundation of the Nile. These frontier districts would naturally be infested with vipers from the Libyan desert, and the vast lakes would as naturally be supplied by numbers of water-fowl, of which the ibis is a species. This bird being likewise an enemy to serpents, the inhabitants would soon become acquainted with his use, and their superstition would soon reward him. In after ages, however, when the ancient improvements were lost, and those vast lakes dried up which brought the ibis thither, the serpents ceased to give any offence, because there were none of the human species there whom they could annoy; and in consequence of the want of water, the birds ceased to annoy them, retiring to their native place Ethiopia, where they continue to frequent the great stagnant pools which are common in that country.

Mr Bruce found a bird in Abyssinia, which, after comparing it with the description of the ancient writers, and the embalmed ibis of Egypt, he concludes is the same with the Egyptian ibis. It is called *abou Hannes*, signifying "father John," from its appearing annually on St John's day.

This bird is minutely described by Mr Bruce. It has a beak shaped like that of a curlew, two-thirds straight, and the remaining third crooked; the upper part of a green horny substance, and the lower part black. It measures four inches and an half from the occiput to the place where it joins the beak. The leg, from the lower joint of the thigh to the foot, is six inches; the bone round and very strong; and from the lower joint of the thigh to where it joins the body, is five inches and a half. The height of the body from the sole to the middle of the back is 19 inches; the aperture of the eye one inch; the feet and legs black; three toes before armed with sharp and straight claws; and a toe behind. The head is brown, and the plumage of the same colour down to the back, or the place where the neck and back are joined. The throat is white, as well as the back, breast, and thighs; the largest feathers of the wing are of a deep black for 13 inches from the tail; and six inches up the back from the extremity of the tail is black likewise.

TANTALUS'S Cup. See HYDROSTATICS, n° 44.

TANZY, or TANSY, in botany. See TANACETUM.

TAORMINA, a town in Sicily, is situated on a rock which rises to a considerable elevation above the level of the sea, and is surrounded by other rocks, the height of which

is still more considerable. It is 88 miles south of Messina, Taormina and was founded by a colony from Naxos, which were probably induced to choose the situation, not so much on account of its grandeur, as for the security which it would afford. It is also very wholesome. The road to Taormina, up the north side of the hill on which it stands, is very steep and difficult of ascent.

Of the origin of Taormina, as of other cities, almost nothing is known. A colony from the isle of Naxos settled at the foot of Etna, at no great distance from the shore, and at about a league or a league and an half from the present situation of Taormina. Dionysius the Tyrant attacked this colony, and either took or set fire to their city. The inhabitants retired to the rocks of Mount Taurus; among which they found a tract of ground sufficiently level, and of sufficient extent, for them to raise habitations upon it. It was a situation in which they might be secure from every attack. Here, therefore, they built a city; which, after the mountain, they named *Tauromenium*. It was at length raised to a very flourishing state by trade, and became celebrated as a seat of the arts. There are still many remains to be seen, which show that the fine arts must have been once successfully cultivated at Tauromenium.

Among other remains of the ancient Tauromenium, still to be seen at Taormina, there is a spacious theatre. Near the theatre is a tomb, and behind the tomb a large natural grotto. The grotto appears to have been anciently adorned within with artificial ornaments. It was possibly consecrated by the Greeks to some rural deity, perhaps to the nymphs, to whom the ancient heathens used generally to consecrate grottoes. After the inhabitants of Taormina embraced Christianity, they still continued to visit this grotto with devout veneration. Instead of the Pagan divinities to whom it had before been sacred, they substituted a saint, the venerable St Leonard, instead of the sportive nymphs. But St Leonard did not long draw crowds to this grotto; and the Christians have either defaced its Pagan decorations, or suffered them to fall into decay by the injuries of time. It is now black and smoky; and it is with difficulty that any remains of the Greek paintings with which it was once ornamented can be distinguished. Perhaps it might be sacred to Pales rather than the nymphs: She was the protectress of flocks; and the circumjacent grounds are, and always have been, excellent for pasture.

There are also to be seen in the neighbourhood of Taormina a variety of tombs, the remains of a gymnasium, with a number of other monuments which still preserve the memory of the ancient Tauromenium.

TAPE-WORM. See TÆNIA.

TAPER, TAPERING, is understood of a piece of timber, or the like, when thick at one end, and gradually diminishing to the other; as is the case in pyramids, cones, &c.

To measure TAPER-Timber, &c. See SLIDING Rule.

TAPER-Bored, is applied to a piece of ordnance when it is wider at the mouth than towards the breech.

TAPER, also denotes a kind of tall wax candle, placed in a candlestick, and burnt at funeral processions, and in other church solemnities.

Tapers are made of different sizes; in some places, as Italy, &c. they are cylindrical; but in most other countries, as England, France, &c. they are conical or taper; whence possibly the name; unless we rather choose to derive taper, in the adjective sense from the substantive taper, in the Saxon *tapen* or *tapon*, *cereus*, "wax-candle." Both kinds are pierced at bottom for a pin in the candlestick to enter.—There are two ways of making tapers, the first with the ladle, the second by hand; for which, see CANDLE.

Paschal

Taormina
||
Taper.

Taper,
Tapestry.

Paschal Taper, among the Romanists, is a large taper, whereon the deacon applies five bits of frankincense, in holes made for the purpose, in form of a cross; and which he lights with new fire in the ceremony of Easter-Saturday.

The Pontifical makes Pope Zosimus the author of this usage; but Baronius will have it more ancient, and quotes a hymn of Prudentius to prove it. That pope he supposes to have only established the use thereof in parish-churches, which, till then, had been restrained to greater churches.

F. Papebroch explains the original of the paschal taper more distinctly, in his *Conatus Chronico-Historicus*, &c. It seems, though the council of Nice regulated the day whereon Easter was to be celebrated, it laid it on the patriarch of Alexandria to make a yearly canon thereof, and to send it to the pope. As all the other moveable feasts were to be regulated by that of Easter, a catalogue of them was made every year; and this was written on a taper, *cereus*, which was blessed in the church with much solemnity.

This taper, according to the abbot Chastelain, was not a wax-candle made to be burnt; it had no wick, nor was it any thing more than a kind of column of wax, made on purpose to write the list of moveable feasts on; and which would suffice to hold that list for the space of a year.

For among the ancients, when any thing was to be written to last for ever, they engraved it on marble or steel; when it was to last a long while, they wrote it on Egyptian paper; and when it was only to last a short time, they contented themselves to write it on wax. In process of time they came to write the moveable feasts on paper, but they still fastened it to the paschal taper. Such is the original of the benediction of the paschal taper.

TAPESTRY, a kind of cloth made of wool and silk, adorned with figures of different animals, &c. and formerly used for lining the walls of rooms, churches, &c.

The art of weaving tapestry is supposed to have been borrowed from the Saracens; accordingly the workmen employed in this manufacture in France were formerly called *Sarazins* or *Sarazinois*. Guicciardini ascribes the invention of tapestry hangings to the inhabitants of the Netherlands; but he has not mentioned at what time the discovery was made. This art was brought into England by William Sheldon, near the end of Henry VIII.'s reign. In 1619 a manufacture was established at Mortlake in Surry by Sir Francis Crane, who received L. 2000 from King James to encourage the design. The first manufacture of tapestry at Paris was set up under Henry IV. in 1606 or 1607, by several artists whom that monarch invited from Flanders. Under Louis XIV. the manufacture of the Gobelins was instituted, which has introduced very beautiful cloths, remarkable for strength, for elegance of design, and a happy choice of colours. The finest paintings are copied, and eminent painters have been employed in making designs for the work.

Tapestry-work is distinguished by the workmen into two kinds, viz. that of high and that of low warp; though the difference is rather in the manner of working than in the work itself; which is in effect the same in both: only the looms, and consequently the warps, are differently situated; those of the low warp being placed flat and parallel to the horizon, and those of the high warp erected perpendicularly. The English anciently excelled all the world in the tapestry of the high warp; and they still retain their former reputation, tho' with some little change: their low warps are still admired; but as for the high ones, they are quite laid aside by the French. The French, before the Revolution, had three considerable tapestry manufactures besides that of the Gobelins; the first at Aubusson in Auvergne, the second

at Felletin in the Upper Marche, and the third at Beauvais. Tapestry. They were all equally established for the high and the low warp; but they had all laid aside the high warp excepting the Gobelins. There were admirable low warps likewise in Flanders, generally exceeding those of France; the chief and almost only Flemish manufactures were at Brussels, Antwerp, Oudenard, Lille, Tournay, Bruges, and Valenciennes; but of the state of these manufactures now we are ignorant.

The usual widths of tapestry are from two ells to three ells Paris measure.

The Manufacture of Tapestry of the High Warp.—The loom on which it is wrought is placed perpendicularly: it consists of four principal pieces; two long planks or cheeks of wood, and two thick rollers or beams. The planks are set upright, and the beams across them, one at the top and the other at the bottom, or about a foot distance from the ground. They have each their trunnions, by which they are suspended on the planks, and are turned with bars. In each roller is a groove, from one end to the other, capable of containing a long round piece of wood, fastened therein with hooks. The use of it is to tie the ends of the warp to. The warp, which is a kind of worsted, or twisted woollen thread, is wound on the upper roller; and the work, as fast as wove, is wound on the lower. Within the planks, which are seven or eight feet high, fourteen or fifteen inches broad, and three or four thick, are holes pierced from top to bottom, in which are put thick pieces of iron, with hooks at one end serving to sustain the coat-stave: these pieces of iron have also holes pierced, by putting a pin in which the stave is drawn nearer or set farther off; and thus the coats or threads are stretched or loosened at pleasure. The coat-stave is about three inches diameter, and runs all the length of the loom; on this are fixed the coats or threads, which make the threads of the warp cross each other. It has much the same effect here as the spring-stave and treddles have in the common looms. The coats are little threads fastened to each thread of the warp with a kind of sliding knot, which forms a sort of mesh or ring. They serve to keep the warp open for the passage of broaches wound with silks, woollens, or other matters used in the piece of tapestry. In the last place, there are a number of little sticks of different lengths, but all about an inch in diameter, which the workman keeps by him in baskets, to serve to make the threads of the warp cross each other, by passing them across; and, that the threads thus crossed may retain their proper situation, a packthread is run among the threads above the stick.

The loom being thus formed, and mounted with its warp, the first thing the workman does is to draw on the threads of this warp the principal lines and strokes of the design to be represented on the piece of tapestry; which is done by applying cartoons made from the painting he intends to copy to the side that is to be the wrong side of the piece, and then, with a black lead pencil, following and tracing out the contours thereof on the thread of the right side; so that the strokes appear equally both before and behind.

As for the original design the work is to be finished by, it is hung up behind the workmen, and wound on a long staff, from which a piece is unrolled from time to time as the work proceeds.

Besides the loom, &c. here described, there are three other principal instruments required for working the silk or the wool of the woof within the threads of the warp; these are a broach, a reed, and an iron needle. The broach is made of a hard wood, seven or eight inches long, and two-thirds of an inch thick, ending in a point with a little handle. This serves as a shuttle; the silks, woollens, gold, or silver, to be used in the work being wound on it. The reed

Tapestry. reed or comb is also of wood, eight or nine inches long, and an inch thick on the back, whence it grows less and less to the extremity of the teeth, which are more or less apart, according to the greater or less degree of fineness of the intended work. Lastly, the needle is made in form of the common needle, only bigger and longer. Its use is to press close the wool and silks when there is any line or colour that does not fit well.

All things being prepared for the work, and the workman ready to begin, he places himself on the wrong side of the piece, with his back towards the design; so that he works as it were blindfold, seeing nothing of what he does, and being obliged to quit his post, and go to the other side of the loom whenever he would view and examine the piece, to correct it with his pressing-needle. To put silk, &c. in the warp, he first turns and looks at the design; then, taking a broach full of the proper colour, he places it among the threads of the warp, which he brings cross each other with his fingers, by means of the coats or threads fastened to the staff; this he repeats every time he is to change his colour. Having placed the silk or wool, he beats it with his reed or comb; and when he has thus wrought in several rows over each other, he goes to see the effects they have, in order to reform the contours with his needle, if there be occasion. As the work advances, it is rolled upon the lower beam, and they unroll as much warp from the upper beam as suffices them to continue the piece: the like they do of the design behind them. When the pieces are wide, several workmen may be employed at once.

We have but two things to add: the first is, that the high warp tapestry goes on much more slowly than the low warp, and takes up almost twice the time and trouble. The second is, that all the difference that the eye can perceive between the two kinds, consists in this, that in the low warp there is a red fillet, about one-twelfth of an inch broad, running on each side from top to bottom, which is wanting in the high warp.

Manufacture of Tapestry of the Low Warp.—The loom or frame, whereon the low warp is wrought, is much like that of the weavers; the principal parts thereof are two strong pieces of wood forming the sides of the loom, and bearing a beam or roller at each end: they are sustained at bottom with other strong pieces of wood in manner of trestles; and, to keep them the firmer, they are likewise fastened to the floor with a kind of buttresses, which prevent any shaking, though there are sometimes four or five workmen leaning on the fore-beam at once.

The rollers have each their trunnions, by which they are sustained: they are turned by large iron pins three feet long. Along each beam runs a groove, wherein is placed the wick, a piece of wood of about two inches diameter, and almost of the length of the roller: this piece fills the groove entirely, and is fastened therein, from space to space, by wooden pins. To the two wicks are fastened the two extremities of the warp, which is wound on the farther roller, and the work, as it advances, on the nearer.

Across the two sides, almost in the middle of the loom, passes a wooden bar, which sustains little pieces of wood, not unlike the beam of a balance: to these pieces are fastened strings, which bear certain spring-staves, wherewith the workman, by means of two treddles under the loom whereon he sets his feet, gives a motion to the coats, and makes the threads of the warp rise and fall alternately. Each loom has more or fewer of these spring-staves, and each staff more or fewer coats, as the tapestry consists of more or fewer threads.

The design or painting the tapestry man is to follow is placed underneath the warp; where it is sustained from

space to space with strings, by means of which the design is brought nearer the warp.

The loom being mounted, there are two instruments used in working it, viz. the reed and the flute. The flute does the office of the weaver's shuttle; it is made of an hard polished wood, three or four lines thick at the ends, and somewhat more in the middle, and three or four inches long. On it are wound the silks or other matters to be used as the woof of the tapestry. The comb or reed is of wood or ivory; it has usually teeth on both sides; it is about an inch thick in the middle, but diminishes each way to the extremity of the teeth: it serves to beat the threads of the woof close to each other, as fast as the workman has passed and placed them with his flute among the threads of the warp.

The workman is seated on a bench before the loom, with his breast against the beam, only a cushion or pillow between them; and, in this posture, separating, with his fingers, the threads of the warp, that he may see the design underneath, and taking a flute, mounted with a proper colour, he passes it among the threads, after having raised or lowered them, by means of the treddles moving the spring-staves and coats.

Lastly, To press and close the threads of the silk or yarn, &c. thus placed, he strikes each course (*i. e.* what the flute leaves in its passing and coming back again) with the reed.

TAPIOCA, a species of starch, which the Brazilians make from the roots of the cassada plant, which is already described under its botanic name *JATROPHA*.

TAPIR, in zoology, a quadruped of the order of *bellua*, resembling the hippopotamus, has the fore-hoofs divided into four, and the hind-hoofs into three parts. The nose of the male extends far beyond the lower jaw, is slender, and forms a sort of proboscis; it is capable of being contracted or extended at pleasure, and its sides are fulcated. The extremities of both jaws end in a point, and there are ten cutting teeth in each. Between them and the grinders there is a vacant space; and there are ten grinders in each jaw. The ears are erect, the eyes small, and the body is shaped like that of a hog. The back is arched; the legs are short; and the hoofs small, black, and hollow. The tail is very small. The animal grows to the size of a heifer half a year old. The hair is short: when young, it is spotted with white; when old, of a dusky colour.—It inhabits the woods and rivers of the eastern side of South America, from the Isthmus of Darien to the river of Amazons. It sleeps during day in the darkest and thickest forest adjacent to the banks, and goes out in the night-time in search of food. It lives on grass, sugar-canes, and on fruits. If disturbed, it takes to the water; swims very well; or sinks below, and, like the hippopotamus, walks on the bottom as on dry ground. It makes a sort of hissing noise.—This is the largest of the American animals.

TAPPING, in general, the act of piercing a hole in a vessel, and applying a tube or canula in the aperture, for the commodious drawing off the liquor contained therein.

TAPPING, in surgery. See **SURGERY**.

TAPROBANE, the ancient name of the island of Ceylon. See **CEYLON**.

TAR, a thick, black, unctuous substance obtained chiefly from old pines and fir-trees by burning them with a close smothering heat. It is prepared in great quantities in Norway, Sweden, Germany, Russia, and North America, and in other countries where the pine and fir abound. For the method of obtaining it, see the article **PINUS**, page 765.

Becher, the celebrated chemist, first proposed to make tar from pit coal. Manufactures for this purpose have been established many years ago in the bishopric of Liege, and 8.

Tapestry
||
Tar.

Taranto in several parts of England. In the year 1781, the earl of Dundonald obtained a patent for extracting tar from pit-coal by a new process of distillation (see COAL, page 80.). Great hopes were entertained of the value of this discovery, but we have not heard that it has answered expectation.

Targionia.

Tar, which is well known for its economical uses, is properly an empyreumatic oil of turpentine, and has been much used as a medicine both internally and externally (see PHARMACY-Index.). Tar-water, or water impregnated with the more soluble parts of tar, was formerly a popular remedy. See PHARMACY, n° 405.

TARANTO, the ancient TARENTUM, a sea-port town of Italy, in the kingdom of Naples, and in the Terra de Otranto. It is a strong and populous place, with an archbishop's see, and the title of a principality. It is seated on a peninsula, and is defended by a strong castle; but the harbour is choaked up. E. Long. 17. 29. N. Lat. 40. 35.

TARANTULA, a species of Aranea, so called from Taranto, the place where they are said to abound. See ARANEA, species 13.

TARASCON, an ancient, populous, and handsome town of France, in the department of the Mouths of the Rhone, and late province of Provence, with a well-built castle, seated on the river Rhone, opposite Beaucaire, with which it communicates by a bridge of boats. Its commerce consists in oil, brandy, starch, and stuffs that are much worn, one sort being of coarse silk, and the other of the same material and wool. It is 10 miles north of Arles, and 375 south by east of Paris. E. Long. 4. 45. N. Lat. 43. 46.

TARAZONA, a strong town of Spain, in the kingdom of Arragon, and on the frontiers of Old Castile, with a bishop's see. It is seated partly on a rock, and partly in a fertile plain, on the river Chiles. It was taken from the Moors in 1110. W. Long. 1. 26. N. Lat. 42. 10.

TARCHONANTHUS, FLEA-BANE, in botany: A genus of plants belonging to the class of *syngenesia*, and to the order of *polygamia aequalis*; and in the natural system ranging under the 49th order, *Composita*. The receptacle is villous, and the pappus plumy: the calyx is monophyllous, turbinate, and half divided into seven segments. There are only three species known; the *camphoratus*, *glaber*, and *ericoides*.

TARE, is an allowance for the outside package that contains such goods as cannot be unpacked without detriment; or for the papers, threads, bands, &c. that inclose or bind any goods imported loose; or though imported in casks, chests, &c. yet cannot be unpacked and weighed neat.

TARE, OR VETCH. See VICIA.

TARGET, a kind of shield or weapon of defence made use of by the ancients.

TARGIONIA, in botany; a genus of plants belonging to the class of *cryptogamia*, and natural order of *algæ*. The calyx is bivalved, including a globular body. There is only one species; the *hypophylla*, which is a native of Great Britain. The hypophylla, or vetch targionia, has leaves about a quarter of an inch long, of a heart-shape, inverted, and growing prostrate in a clump together: their upper surface is green, covered with whitish papillæ, and their lower surface is black. The fructification grows at the great end of the leaf on the lower side, and consists of two concave valves or hemispheres, of a reddish black colour, inclosing a chocolate-coloured globule, resembling the seed of a tare or vetch, full of a yellow powder. The leaves increase by shooting out young offsets from their sides like the polypus. This plant is found in the north of England, and near the Tarbet of Cantire in Scotland.

TARGUM, a name given to the Chaldee paraphrases of the books of the Old Testament. They are called *paraphrases* or *expositions*, because they are rather comments and explications than literal translations of the text. They are written in the Chaldee tongue, which became familiar to the Jews after the time of their captivity in Babylon, and was more known to them than the Hebrew itself. So that when the Hebrew text was read in the synagogue, or in the temple, they generally added to it an explication in the Chaldee tongue for the service of the people, who had but a very imperfect knowledge of the Hebrew tongue. It is probable, that even from the time of Ezra this custom began, since this learned scribe, reading the law to the people in the temple, explained it, with the other priests that were with him, to make it understood by the people (Nehem. viii. 7-9.).

But though the custom of making these sorts of expositions in the Chaldee language be very ancient among the Hebrews, yet have they no written paraphrases or targums before the era of Onkelos and Jonathan, who lived about the time of our Saviour. Jonathan is placed about 30 years before Christ, under the reign of Herod the Great. Onkelos is something more modern. The targum of Onkelos is the most of all esteemed, and copies are to be found in which it is inserted verse for verse with the Hebrew. It is so short and so simple, that it cannot be suspected of being corrupted. This paraphrast wrote only upon the books of Moses; and his style approaches nearly to the purity of the Chaldee, as it is found in Daniel and Ezra. This targum is quoted in the *misna*, but was not known either to Eusebius, St Jerome, or Origen.

The targum of Jonathan son of Uziel is upon the greater and lesser prophets. He is much more diffuse than Onkelos, and especially upon the lesser prophets, where he takes great liberties, and runs on in allegories. His style is pure enough, and approaches pretty near to the Chaldee of Onkelos. It is thought that the Jewish doctors who lived above 700 years after him made some additions to him.

The targum of Joseph the Blind is upon the Hagiographa. This author is much more modern, and less esteemed than those we have now mentioned. He has written upon the Psalms, Job, the Proverbs, the Canticles, Ecclesiastes, Ruth, and Esther. His style is a very corrupt Chaldee, with a great mixture of words from foreign languages.

The targum of Jerusalem is only upon the Pentateuch; nor is that entire or perfect. There are whole verses wanting, others transposed, others mutilated; which has made many of opinion that this is only a fragment of some ancient paraphrase that is now lost. There is no targum upon Daniel, or upon the books of Ezra and Nehemiah.

These targums are of great use for the better understanding not only of the Old Testament, on which they are written, but also of the New. As to the Old Testament, they serve to vindicate the genuineness of the present Hebrew text, by proving it to be the same that was in use when these targums were made, contrary to the opinion of those who think the Jews corrupted it after our Saviour's time. They help to explain many words and phrases in the Hebrew original, and they hand down to us many of the ancient customs of the Jews. And some of them, with the phraseologies, idioms, and peculiar forms of speech, which we find in them, do in many instances help as much for the better illustration and better understanding of the New Testament as of the Old; the Jerusalem Chaldee dialect, in which they are written, being the vulgar language of the Jews in our Saviour's time. They also very much serve the Christian cause against the Jews, by interpreting many of the prophecies of the Messiah in the Old Testament in the same manner

Tarif manner as the Christians do. Many instances are produced to this purpose by Dr Prideaux in his *Connec. of the Hist. of the Old and New Test.* vol. iv. p. 777, &c.

Tartary. These targums are published to the best advantage in the second edition of the great Hebrew Bible set forth at Basil by Buxtorf the father, anno 1610; for he has rectified the Chaldee text, and reformed the vowel pointings in it: the targums having at first been written without vowel points, which were afterwards added very erroneously by some Jews.

TARIF, a table or catalogue containing the names of different sorts of merchandize, with the duties to be paid as settled by authority amongst trading nations.

TARPA (Spurius Mecijs), a Latin critic in the time of Julius Cæsar and Augustus. He had his tribunal in the temple of Apollo, where, with four assistants, he passed sentence on the works of the poets. Cicero and Horace make honourable mention of this critic.

TARPAULIN, a piece of canvass, well tarred over, to keep off the rain from any place. The term is also often applied in a burlesque sense to a person that has been all his life bred to the sea.

TARPEIAN, in Roman antiquity, an appellation given to a steep rock in Rome; whence, by the law of the twelve tables, those guilty of certain crimes were precipitated. It took its name from Tarpeia, a vestal virgin, who was killed by the Sabines, as related under the article **ROME**, n° 24.

TARQUIN the ELDER, king of Rome, succeeded Ancus Martius 615 B. C. See **ROME**, n° 35—40.

TARQUIN the Proud, a tyrant and usurper. See the article **ROME**, n° 49—51, &c.

TARRAGON, or **DRAGON-WORT**. See **ARTEMISIA**.

TARROCK, in ornithology, a species of **LARUS**.

TARSHISH, or **TARTESSUS**, a town frequently mentioned by ancient authors, the situation of which it is difficult to ascertain. See the opinions of Mr Bruce and Dr Doig on this subject under the article **OPHIR**.

TARTAN, in sea language, a small coasting vessel navigated in the Mediterranean sea, and having only one mast and a bowsprit, the principal sail, which is extremely large, being extended by a lateen-yard. When tartans put up a square sail, it is called a *sail of fortune*.

TARTAR, a hard solid substance which separates from wine after complete fermentation, and adheres to the top and sides of the casks. See the *Index* to **CHEMISTRY** and **PHARMACY**.

TARTARY, a very large country of Asia, situated between 57° and 160° of E. Long. reckoning from the west end of the isle of Ferro, and between 37° and 55° of Lat. It is bounded on the north by Siberia, or that part of Asia which belongs to Russia; on the west by the rivers Don, Wolga, and Kama, which separate it from Russia; on the south by the Euxine and Caspian Seas, Karazm, the two Bukharias, China, and Korea; and on the east, by the Oriental or Tartarian ocean. It extends from east to west the space of 104 degrees in longitude, or 4145 geographical miles; but its breadth is not proportionable, being not above 960 miles where broadest, and where narrowest 330.

This vast region is divided into two great parts; the one called the *Western*, the other the *Eastern Tartary*.

Western Tartary, which is much more extensive than the Eastern, containing 139 degrees of longitude out of 161, is inhabited by a great number of nations, or tribes of people, who are called *Mungls* or *Mungals*, by themselves; and *Moguls* or *Tartars*, indifferently, by other nations.

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The principal mountains, or rather chains of mountains, found in this part of Great Tartary, may be divided into three classes: first, those which run along the northern borders of it; and though perhaps not always contiguous, or of the same denomination, go under the general name of *Ulug Tag*, or *Dag*, that is, the *Great Mountain*. Secondly, those which make the southern bounds, and are called *Kichug Tag*, or the *Lesser Mountain*. The third great chain is called *Mount Altay*, lying nearly in the middle, between the Caspian Sea and Eastern Tartary, and extending between the other two, in about the 110th degree of longitude.

The principal rivers of Western Tartary, besides the Dnieper, Don, and Wolga, are the Jaik or Yaik, and Yem, both descending from the Ulug Tag, and falling into the Caspian Sea on the north side: the river Ili or Khonghis, which rises out of the Kichug Tag, on the borders of Little Bukharia, and runs north-west into the lake Palkasi, which is about forty miles long, and 30 broad, in latitude 48°, longitude 97°, reckoning from the isle of Ferro: on this river the khan of the Eluths or Kalmucks usually resides: the river Irtysh, Irtyis, or Erchis, which rises in Mount Altay, and runs westward, inclining to the north, between two branches of it, into the lake Sayfan, Sassan, or Ifan, called also *Honhotu-Nor*, 90 miles long from west to east, and 40 broad, in latitude 47° 30', longitude 104°; from whence issuing again, it passes north-west, through part of Siberia, and falls into the Oby, which has its source in the same mountain, about one degree to the north of that of the Irtysh; and seven or eight degrees to the north-east rises the Kem or Jenisea, which runs westward for the space of seven or eight degrees, and then turning northward enters Siberia. The next river of note is the Selinga, which rises out of the lake Kofogol, Hutuktu or Khutuktu, which is 70 miles long from south to north, and 20 broad, in latitude 52°, longitude 118°, not far from the source of the Jenisea, and taking a sweep southward, round by the east, falls northward into the lake Baykal in Siberia, about 30 leagues north-west of the city Selinghinskoy, which stands upon it. Into the Selinga runs the Orkon, coming from the south-west; and into the Orkon the Tula, rising eastward in Mount Kentey. On the same mountain rises also two other rivers, viz. the Onon, called also by the Tartars *Saghalian Ula*, or the Dragon river, and by the Russians *Amur*; which running north-eastward, and then taking a large sweep by the south, rolls along the bounds of Eastern Tartary, and falls into the Eastern Ocean. On its banks stand two cities; Nerchinskoy or Nipchew, a frontier of the Russians, almost due north of Pekin in China; and Saghalian Ula, possessed by the Chinese. Another large river is the Kerlon or Kerulon, which running north-eastward, falls into the lake Kulon or Dalay, which is 60 miles long from south-west to north-east, and 27 broad, in latitude 48° 30', longitude 135°, and issuing out again under the name of *Ergona* or *Argun*, joins the Saghalian Ula, about 170 miles beyond Nerchinskoy. To these let us add the river Kalka, from whence, though small, the Kalka-Moguls or Mongols take their name. It rises in the mountains, separating Eastern from Western Tartary, and, running eastward, falls into the lake Puir, and then into that of Kulon, before spoken of.

In the middle of a desert, on the banks of the river Irtysh, is a remarkable piece of antiquity called **SEDMY PALATY**, or the *seven palaces*.

Above the Sedmy Palaty, towards the source of the Irtysh, grows the best rhubarb in the world, without the least culture. In the plain of this country also, about eight or ten days journey from Tomsky in Siberia, are found many

R r

tombs

Tartary. tombs and burying-places of ancient heroes, who in all probability fell in battle. These tombs are easily distinguished by the mounds of earth and stone raised over them. The Tartars say, Tamerlane had many engagements in this country with the Kalmucks, whom he in vain endeavoured to conquer. Many persons go from Tomsky, and other parts, every summer, to these graves, which they dig up, and find among the ashes of the dead considerable quantities of gold, silver, brass, and some precious stones, but particularly hilts of swords and armour. They find also ornaments of saddles and bridles, and other trappings for horses; and sometimes those of elephants. Whence it appears, that when any general or person of distinction was interred, all his arms, his favourite horse and servant, were buried with him in the same grave; this custom prevails to this day among the Kalmucks and other Tartars, and seems to be of great antiquity. It appears from the number of graves, that many thousands must have fallen, in those places; for the people have continued to dig for treasure many years, and still find it unexhausted. They are, indeed, sometimes interrupted, and robbed of all their booty, by parties of Kalmucks, who abhor disturbing the ashes of the dead. Armed men on horseback, cast in brass, of no mean design and workmanship, with the figures of deer cast in pure gold, have been dug out of these tombs. They once discovered an arched vault, where they found the remains of a man, with his bow, lance, and other arms, lying on a silver table. On touching the body, it fell to dust. The value of the table and arms was very considerable. For the manners and customs of these Tartars, see KALMUCKS.

Great quantities of a kind of ivory, called by the natives *Mammons-horn*, are found in this country and in Siberia, on the banks of the Oby. They are commonly found on the banks of rivers that have been washed by floods. Some of them are very entire and fresh, like the best ivory in all respects, excepting only the colour, which is of a yellowish hue. In Siberia they make snuff-boxes, combs, and divers sorts of turnery ware of them. Some have been found weighing above 100 pounds English.

The most considerable tribes in Western Tartary, next to the Kalmucks, are the Kalkas and Mungls, or Mongals, properly so called. The country of the Kalkas extends eastward, from mount Altay to the source of the river Kalka, whence they derive their name, in the borders of Eastern Tartary, and 139th degree of longitude. The territories of the Mungls, or Mongalia, lie to the south of those of the Kalkas, between them and the great wall of China, to which empire both nations are subject. Besides these tribes, who are idolaters of the religion of the Delay Lama, there are others, who possess that part of Western Tartary called *Turkestan*, the original country of the Turks and Turkmans, situated to the north of Great Bukharia and Karazm, between those countries and the dominions of the Eluths. Under Western Tartary also is comprehended Tibet, Thibet, or Tobbut, subject to the Delay Lama, or great high-priest of the Pagan Tartars and Chinese.

In all the vast region of Western Tartary, there are but few towns, most of the inhabitants living under tents, especially in summer, and moving from place to place with their flocks and herds. They generally encamp near some river for the convenience of water.

The air of this country is temperate, wholesome, and pleasant, being equally removed from the extremes of heat and cold. As to the soil, though there are many mountains, lakes, and deserts in it, yet the banks of the rivers, and the plains, some of which are of great extent, are exceeding fertile. The mountains, woods, and deserts, abound with venison, game, and wild fowl; and the rivers and lakes both

with fish and fowl. In particular, here are wild mules, horses, and dromedaries, wild boars, several kinds of deer, a species of goats with yellow hair, squirrels, foxes; an animal called *hauteban*, resembling an elk; another called *chulon* or *chelifon*, that seems to be a sort of lynx; and a creature called *tael-pe*, as small as an ermine, of whose skins the Chinese make mantles to keep out the cold. Among other birds of extraordinary beauty, bred in this country, there is one called the *shonkar*, which is all over white except the beak, wings, and tail, which are of a very fine red. Notwithstanding the soil in many parts of Tartary is so luxuriant, yet we are told it does not produce a single wood of tall trees of any kind whatever, excepting in some few places towards the frontiers; all the wood that is found in the heart of the country consisting of shrubs, which never exceed the height of a pike, and even these are rare.

It is remarkable, that in all the vast dominions of Mongalia, there is not so much as a single house to be seen. All the people, even the prince and high-priest, live constantly in tents, and remove their cattle from place to place as convenience requires. These people do not trouble themselves with ploughing or digging the ground in any fashion, but are content with the produce of their flocks, though the soil is exceeding fine, and capable, by proper culture, of producing grain of several sorts.

In the country of the Mongals the grass is very thick and rank, and would with little labour make excellent hay. This grass is often set on fire by the Mongals in the spring during high winds. At such times it burns most furiously, running like wild-fire, and spreading its flames to the distance of perhaps 10 or 20 miles, till its progress is interrupted by some river or barren hill. The rapidity of those flames, their smoke and crackling noise, cannot easily be conceived by those who have not seen them. When any person finds himself to the leeward of them, the only method by which he can save himself from their fury, is to kindle immediately the grass where he stands, and follow his own fire. For this purpose, every person is provided with flints, steel, and tinder. The reason why the Mongals set fire to the grass, is to procure early pasture to their cattle. The ashes left upon the ground sink into the earth at the melting of the snow, and prove an excellent manure; so that the grass in the spring rises on the lands which have been prepared in this manner as thick as a field of wheat. Caravans, travellers with merchandise, but especially armies, never encamp upon this rank grass; and there are several instances of considerable bodies of men being put in confusion, and even defeated, by the enemy's setting fire to the grass.

Eastern Tartary, according to the limits usually assigned it by historians and geographers, is bounded to the west by Western Tartary, or by that part possessed by the proper Mungls and Kalkas; on the north by Siberia; on the east by that part of the Oriental Ocean called the *Tartarian Sea*; and on the south by the same sea, the kingdom of Korea, and the Yellow Sea, which separates it from China. It is situated between the 137th and 160th degrees of longitude, being about 900 miles long from south to north, and near as many in breadth from west to east, yet but thinly peopled. This large region is at present divided into three great governments, all subject to the Chinese, viz. Shing-yang or Mugden, Kurin-ula, and Tiflikar.

The government of Shin-yang, containing all the ancient Lyau-tong or Quan-tong, is bounded on the south by the great wall of China and the Yellow Sea; on the east, north, and west, it is inclosed by a wooden palisade, seven or eight feet high, fitter to mark its bounds and keep out petty robbers than to oppose an army.

Tartary.

The lands of this province are for the general very fertile, producing abundance of wheat, millet, roots, and cotton. They also afford pasture to great numbers of sheep and oxen, which are rarely seen in any of the provinces of China. They have indeed but little rice; yet, to make amends, there is plenty of apples, pears, hazel-nuts, filberds, and chesnuts, even in the forests. The eastern part, which borders on the ancient country of the Manchews and kingdom of Korea, is full of deserts and bogs. The principal cities of this government are Shing-yang or Mugden, Fong-whang ching, Inden, Ichew, and Kingchew. This country was the original seat of the Tartar tribe of the Manchews, who have been masters of China above 100 years.

The government of Kirin-ula-hotun is bounded westward by the palifade of Lyau-tong; on the east, by the Eastern Ocean; southward, by the kingdom of Korea; and on the north by the great river Saghalian; so that it extends no fewer than 12 degrees, and almost 20 degrees in longitude, being 750 miles in length and 600 in breadth.

This vast country abounds in millet and oats, with a sort of grain unknown in Europe, called by the Chinese *may-sem-mi*, as being of a middle kind between wheat and rice. It is wholesome, and much used in those cold regions. There is but little wheat or rice here; but whether that is the fault of the soil or the inhabitants, we cannot assert. The cold begins much sooner in these parts than at Paris, whose latitude is near 50 degrees. The forests, which are very thick and large the nearer you advance to the Eastern Ocean, contribute not a little to bring it on and keep it up. The banks of the rivers here, in summer, are enamelled with a variety of flowers common in Europe, excepting the yellow lilies, which are of a most lively colour, in height and shape exactly resembling our white lilies, but are of a much weaker scent. But the plant which is most esteemed, and draws a great number of herbalists into these deserts, is the gin-seng*, called by the Manchews *orbota*, that is, the chief or queen of plants. It is highly valued for its virtues in curing several diseases, and all decays of strength proceeding from excessive labour of body or mind. For this reason it has always been the principal riches of Eastern Tartary; what is found in the north of Korea being consumed in that kingdom.

Formerly the Chinese used to get into the gin-seng country among the mandarins and soldiers continually passing; but in 1700 the emperor Kang-hi, that his Manchews might reap this advantage, ordered 10,000 of his soldiers, encamped without the great wall, to go and gather it, on condition that each should give him two ounces of the best, and take an equal weight of fine silver for the remainder: by which means the emperor got in that year 20,000 pounds of it for less than one-fourth of the price it bears at Pekin. The root is the only part that is used medicinally. Its value is enhanced by its age, for the largest and firmest are the best. This country abounds also in fine fables, grey ermines, and black foxes.

One of the tribes of Tartars inhabiting this country are called the *Yu-pi Tartars*, whose manner of life is somewhat extraordinary. All the summer they spend in fishing: one part of what they catch is laid up to make oil for their lamps; another serves for their daily food; and the rest, which they dry in the sun, without salting, for they have no salt, is laid up for their winter's provisions, whereof both men and cattle eat when the rivers are frozen. Notwithstanding this diet, a great deal of strength and vigour appears in most of these poor people. Their raiment consists of the skins of fish, which, after dressing and dyeing of three or four colours, they shape and sew in so delicate a manner, that one would imagine they made use of silk, till,

on ripping a stitch or two, you perceive an exceeding fine thong, cut out of a very thin skin. When the rivers are frozen, their sledges are drawn by dogs trained up for the purpose, and highly valued.

Although the Manchew language is as much used at the court of Pekin as the Chinese, and all public acts are drawn up in the one as well as the other; yet it began to decline, and would probably have been lost, had not the Tartars taken great pains to preserve it, by translating Chinese books, and compiling dictionaries, under the emperor's patronage. Their language is singular in this respect, that the verb differs as often as the substantive governed by it; or, which is the same thing, to every different substantive they use a different verb; as for instance, when they would say, *make a verse, a picture, a statue*; for though the repetition of the same verb in discourse might be excusable, it is with them unpardonable in writing, as making a monstrous grating to their ears.

Another singularity of their language is the copiousness of it; for instance, besides names for each species of animals, they have words to express their several ages and qualities. *Judagon* is the general name for a dog; but *tayba* signifies a dog who has very long and thick hair both on his ears and tail; and *yolo*, a dog with a long thick muzzle and tail, large ears, and hanging lips. The horse, as more serviceable to them, has 20 times more names than the dog; almost every motion of him giving occasion to a different name. Where they could get that astonishing multitude of names and terms, is not easy to determine.

This country is but thinly peopled, and contains only four cities, namely, Kirinula-hotun or Khotun, Pedne or Petuna, Ninguta, and Putay-ula-hotun, which are very ill-built, and encompassed with no better than mud-walls. The first stands on the river Songari, and is the residence of the Manchew general, who has all the privileges of a viceroy, and commands the mandarines as well as the troops. Ninguta, which the family now reigning in China considers as its ancient patrimony, is situated on the Hurkapira, which runs northward into the Songari. Its name is compounded of two Tartarian words which signify seven chiefs, to express the rise of the Manchew kingdom, which was first established by seven brothers of the late emperor Kanghi's great-grandfather's father.

The tribe of the Manchews, who inhabit a part of Eastern Tartary, and are lords of all the other inhabitants thereof, are called by the Russians *Bogdoy*, and the emperor of China *Bogdoy Khan* and *Amulon Bogdoy Khan*.

The third government into which Eastern Tartary is divided, is that of Tifitkar. It is 740 miles long and 600 broad; and belongs partly to China and partly to Russia. The people are great hunters, dexterous archers, and pay their tribute in sable-skins; each family being assessed two or three, or more a-year, according to the number of able persons.

This province is inhabited chiefly by three sorts of Tartars, the Manchews, the Solons, and Taguri, of whom the first are masters. The Taguri are a large robust people, but not very numerous. They live in houses or huts, and cultivate barley, oats, and millet. Their cattle are principally horses, dromedaries, oxen, cows, and sheep. They make much use of their oxen to ride on.

The Solons also are a brave robust people. Their dress is a short jacket of wolves skins, with a cap of the same; and they have long cloaks made of fox or tigers skins, to defend them against the cold, especially of the night. They hang their bows at their backs. Their women ride on horseback, drive the plough, hunt stags and other game.

Besides the country towns or villages, there are three ci-

Tartary.

* See *Pa-*
max.

Tartary. ties in the province of Tsfikar, namely, Tsfikar, Merghen, and Saghalian-ula-hotun. The garrison of Tsfikar, the capital, consists of Manchews; but the inhabitants are mostly Chinese. According to their own account, they are all shamams, or conjurors, and invoke the devil with frightful cries. They give their dead two burials, first leaving a hole at top of the grave, where the relations daily bring victuals, which they convey to the mouth of the deceased with a spoon, and leave drink in small tin cups standing round the grave. This ceremony holds for several weeks, after which they bury the body deeper in the ground.

Several rivers in this country produce pearls, which, though much cried up by the Tartars, would be little valued by Europeans, on account of their defects in shape and colour.

The kingdoms or countries of Corea, Lyau-tong, and Nyu-che, forming a part of Katay, Kitay, or Cathay, and by some included under Eastern Tartary, are more properly provinces of China, though they lie without the great wall.

Usbeck Tartary. To the north and north-east of Persia lie the countries of Karasm, and Great and Little Bukharia, which being mostly subject to and inhabited by the tribe of Usbeck Tartars, are commonly known by the general name of *Usbeck Tartary*.

The kingdom of Karasm was known to the ancient Greeks, as appears from Herodotus, Ptolemy, and other authors of that nation, by the name of *Khorasmia*. At present it is bounded on the north by the country of Turkestan, and the dominions of the great khan of the Eluths or Kalmucks; on the east, by Great Bukharia, from which it is separated partly by the mountains of Irdar, and partly by the deserts of Karak and Gaznah; on the south, by the provinces of Astarabad and Khorassan, belonging to Iran or Persia at large, from which it is divided by the river Jihun or Amu, and sundry deserts of a vast extent; and on the west by the Caspian Sea.

It may be about 440 miles in length from south to north, and 300 from west to east; being situated between the 39th and 46th degrees of north latitude, and the 71st and 77th degrees of east longitude. The country consists, for the most part, of vast sandy plains, some of which are barren deserts, but others afford excellent pasture. There is good land in several of the provinces, where vines grow, and wine is made; but water being scarce, a great part of the country turns to no account.

Karasm owes all its fertility to three rivers and a lake. The rivers are the Amu, Khafil, and Sir. The Amu, as it is called by the Usbecks and Persians, is the Jihun of the Arabs, and Oxus of the ancient Greeks. It has its source in those high mountains which separate Little Bukharia from the dominions of the Great Mogul; and, after passing through Great Bukharia and Karasm, divides into two branches, one of which falls into the Khafil, and the other into the Caspian Sea, towards the borders of the province of Astarabad. The Amu abounds with all sorts of excellent fish, and its banks are the most charming in the world. Along them grows those excellent melons and other fruits so much esteemed in Persia, the Indies, and Russia.

The river Khafil rises in the mountains to the north-east of the province of Samarkant, and falls into the lake of Aral or Eagles, 50 or 60 miles below its junction with a branch of the Amu. Its banks are exceeding fertile wherever they are cultivated.

The Sir or Daria rises in the mountains to the east of Little Bukharia, and after a long course westward, along the borders of the Bukharias and Karasm, falls at last into the lake Aral.

Karasm is at present inhabited by three sorts of people, **Tartary.** the Sarts, Turkmans, and Usbeck Tartars. With regard to the first of these, we are told, that they are the ancient inhabitants of the country, or those who were settled there before the Usbecks became masters of it; and that they support themselves like the Turkmans by their cattle and husbandry. The Turkmans or Turkomans came originally from Turkestan or the parts of Tartary to the north of Karasm and Great Bukharia, towards the 11th century. They divided into two parties; one of which went round the north side of the Caspian Sea, and settled in the western parts of the Greater Armenia, from thence called *Turkomania*, or *the country of the Turkomans*. The second party turned south, and rested about the banks of the river Amu and the shores of the Caspian Sea, where they still possess a great many towns and villages, in the countries of Karasm and Astarabad.

The name of *Usbecks*, which the ruling tribe of the Tartars of Karasm and Great Bukharia bear at present, is derived from one of their khans. The Usbecks of Karasm are divided into several hords, and live for the most part by rapine; resembling in all respects those of Great Bukharia, excepting that they are much more rude and uncivilized. Like the Turkmans, they dwell in winter in the towns and villages which are towards the middle of Karasm; and in summer the greater part of them encamp in the neighbourhood of the Amu, or in other places where they can meet with pasture for their cattle, always watching for some convenient opportunity to rob and plunder. They never cease making incursions upon the adjacent territories of Persia or Great Bukharia, and are to be restrained by no treaties or engagements whatsoever. Although they have fixed habitations, yet, in travelling from one place to another, they carry with them all their effects of value, conformable to the way of living in use among their ancestors before they had settled dwellings.

These Tartars, it is said, never ride without their bows, arrows, and swords, although it be in hawking or taking any other diversion. They have no arts or sciences among them, neither do they till or sow. They are great devourers of flesh, which they cut in small pieces, and eat greedily by handfuls, especially horse flesh.

Their chief drink is sour mare's milk, like that in use with the Nogays. They eat their victuals upon the ground, sitting with their legs double under them, which is their posture also when they pray.

All these tribes have abundance of camels, horses, and sheep, both wild and tame. Their sheep are extraordinary large, with great tails weighing 60 or 80 pounds. There are many wild horses in the country, which the Tartars frequently kill with their hawks. These birds are taught to seize upon the head or neck of the beast; which being tired with toiling to get rid of this cruel enemy, the hunter, who follows his game, comes up and kills him. Some travellers tell us, that the inhabitants of this country have not the use of gold, silver, or any other coin, but barter their cattle for necessaries. Others tell us, that they have money, particularly a piece of silver called *tanga*, the value near the fourth part of a crown. It is round, and has on one side the name of the country, and on the other that of the khan, with the year of the hegira. There are also, it is said, small pieces of copper, of different sizes, which answer to our pence, half-pence, and farthings.

As to the government of Karasm, the Usbecks being masters, it is commonly vested in divers princes of that tribe of the same house; of whom, notwithstanding, only one has the title of *khan*, with a kind of superiority over the others.

This

Tartary. This khan has no sort of dependence on him of Great Bukharia, or any other prince.

Bukharia, Bokharia, Bokaria, Bogaria, or Boharia, is the name given to all that region or tract of land lying between Karasm and the Great Kobi, or Sandy Desert, bordering on China. It is divided into the Great and Little Bukharia. For an account of which, see the article BUKHARIA.

The inhabitants of these different countries, which are known by the name of *Tartary*, have a tradition among themselves that they are all sprung from one common stock, and that they are of the most remote antiquity. To this tradition much credit is due; for they are known to be the descendants of the ancient Scythians. But when M. Bailly contends that the Tartars are the most ancient of nations, and the civilizers of mankind, he writes without authority, and advances a paradox at which every mind must recoil. Among the Tartars there are no historical monuments of antiquity and credit; for all their writings extant, even those in the Mogul dialect, are long subsequent to the time of Mohammed; nor is it possible, says Sir William Jones, to distinguish their traditions from those of the Arabs, whose religious opinions they have in general adopted. M. Bailly displays indeed great learning and ingenuity in his attempt to derive civilization from this source; but the greatest learning and acuteness, together with the charms of a most engaging style, can hardly render tolerable a system, which places an earthly paradise, the gardens of *Hesperus*, the islands of the *Maccarees*, the groves of Elysium, if not of Eden, the heaven of *INDRA*, the Peristan or fairy-land of the Persian poets, with its city of diamonds and its country of *Shadcam*, so named from Pleasure and Love, not in any climate which the common sense of mankind considers as the seat of delights, but beyond the mouth of the Oby, in the Frozen Sea, in a region equalled only by that where the wild imagination of Dante led him to fix the worst of criminals in a state of punishment after death, and of which he could not, he says, even think without shivering.

Before the era of Mohammed the Tartars had no literature. The magnificent Chengiz, whose empire included an area of near 80 square degrees, could find none of his own Mongals, as the best authors inform us, able to write his dispatches; and *TIMUR* or *TAMERLANE*, a savage of strong natural parts, and passionately fond of hearing histories read to him, could himself neither write nor read. It is true, that by some Arabian writers mention is made of a set of Tartarian characters, said to consist of 41 letters; but from the description of these characters, Sir William Jones, with much plausibility, suspects them to have been those of Tibet.

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“From ancient monuments therefore (continues the learned president) we have no proof that the Tartars were themselves well instructed, much less that they instructed the world; nor have we any stronger reason to conclude from their general manners and character, that they had made an early proficiency in arts and sciences; even of poetry, the most universal and most natural of the fine arts, we find no genuine specimens ascribed to them, except some horrible war-songs expressed in Persian by Ali of Yezd, and possibly invented by him. After the conquest of Persia by the Mongals, their princes indeed encouraged learning, and even made astronomical observations at Samarkand; as the Turks became polished by mixing with the Persians and Arabs, though *their very nature, as one of their own writers confesses, had before been like an incurable distemper, and their minds clouded with ignorance*: thus also the Manchu monarchs of China have been patrons of the learned and ingenious, and the emperor Tien-Long is, if he be now living, a fine Chinese poet. In all these instances the Tartars have resembled the Romans, who, before they had subdued

Greece, were little better than tigers in war, and Fauns or Sylvans in science and art.

“We may readily believe those who assure us, that some tribes of wandering Tartars had real skill in applying herbs and minerals to the purposes of medicine, and pretended to skill in magic: but the general character of their nation seems to have been this; they were professed hunters or fishers, dwelling, on that account, in forests or near great rivers, under huts or rude tents, or in waggons drawn by their cattle from station to station; they were dexterous archers, excellent horsemen, bold combatants, appearing often to flee in disorder for the sake of renewing their attack with advantage; drinking the milk of mares, and eating the flesh of colts; and thus in many respects resembling the old Arabs, but in nothing more than in their love of intoxicating liquors, and in nothing less than in a taste for poetry and the improvement of their language.”

Krim TARTARY. See CRIMEA.

TASSEL, a sort of pendant ornament at the corners of a cushion or the like. In building, tassels denote those pieces of board that lie under the ends of the mantlet trees.

TASSO (Torquato), a justly celebrated Italian poet, was born at Sorrento in the kingdom of Naples, in 1544. He was the son of Bernardo Tasso, the author of several ingenious compositions both in verse and prose; and of Portia de Roffi, a lady of an illustrious family of Naples.

His father being obliged to accompany the prince of Salerno to the emperor Charles V. upon a deputation from Naples to remonstrate against erecting the inquisition there, committed the care of his son, then three years old, to Angeluzza, a man of great learning; who, we are told, at this tender age began to teach him grammar: at four he was sent to the Jesuit's college, and at seven was well acquainted with Latin and Greek. At 12 years of age he went from Rome to Mantua, where his father had entered into the service of the duke Guglielmo Gonzago: he had then completed his knowledge of the Latin and Greek languages; he was well acquainted with rhetoric and poetry, and a master of Aristotle's ethics; he had also studied the precepts of Mauritio Cataneo with particular attention, and ever after revered him as a second father.

He was soon after sent to the university of Padua; and, in his 18th year, published his *Rinaldo*, a poem written upon the plan of Homer's *Odyssey*. This extended his reputation throughout all Italy; but greatly displeased his father, who foresaw that it would seduce him from studies of more advantage. He went to Padua, to remonstrate against his apparent purpose of giving himself up to philosophy and poetry, and made use of many very harsh expressions, which Tasso heard with a patience and tranquillity that made the old gentleman still more angry: “Of what use is that philosophy on which you value yourself so much?” “It has enabled me (replied Tasso) to endure the harshness of your reproofs.”

He soon after went to Bologna, by the invitation of the city and college; but in a little time returned to Padua at the pressing instances of Scipio Gonzaga, who had been elected prince of the academy that had been established in that city by the name of the *Ætherei*. He was incorporated into this society, and took upon himself the name of *Pentito*.

In this retreat he formed the design of his *Jerusalem Delivered*, invented the fable, disposed the parts, and determined to dedicate it to the house of Este; but whether to Alphonso II. the last duke of Ferrara, or his brother the cardinal Luigi, to whom he had already dedicated his *Rinaldo*, he was yet in doubt. Being pressed by both the brothers to reside with them at Ferrara, he consented. The duke

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Tasso. duke gave him an apartment in his palace, where he lived in peace and affluence, and prosecuted his work; which he now determined to dedicate to the duke, and which was published by his patrons, book by book, as he finished them.

When he was about 27, he published a pastoral comedy called *Aminta*; which was received with universal applause, as a masterpiece in its kind, and is the original of the *Pastor Fido* and *Filli di Sciro*.

In the 30th year of his age he finished his *Jerusalem*, and the whole was reprinted and published together: the success of it was astonishing; it was translated into Latin, French, Spanish, and even the Oriental languages, almost as soon as it appeared.

But it was Tasso's fate to become wretched from the moment that he gained the summit of reputation: very soon after his *Jerusalem* was published, he lost his father, who died at Ostia upon the Po, the government of which place had been given him by the duke of Mantua; his *Jerusalem* was attacked by a swarm of ignorant but petulant critics, who gave the preference to the rhapsodies of Pulci and Boyardo; and the perfidy of a friend drew upon him much greater misfortunes.

This friend was a gentleman of Ferrara, to whom Tasso had indiscreetly communicated some transactions of a very delicate nature concerning his patron the duke, with whom he lived. This secret being betrayed, Tasso reproached his friend for his treachery; and this reproach was retorted in such a manner as provoked Tasso to strike him. A challenge immediately ensued, and the opponents met and engaged; but during the rencounter, three brothers of Tasso's antagonist came up, and all fell upon him together: Tasso defended himself so well, that he wounded two of them, and kept his ground against the others till some people came up and parted them. This made a great noise at Ferrara, where nothing was talked of but the valour of Tasso; and it became a kind of proverb, "That Tasso, with his pen and his sword, was superior to all men."

The duke being informed of the quarrel, banished the brothers from his dominions, confiscated their estates, and Tasso himself he shut up in prison, under pretence of securing him from any future attacks of his enemies.

Tasso found means to escape from this confinement, after having suffered it about a year; and, being now about 34 years of age, retired to Turin, where he was soon known and recommended to the duke of Savoy, who showed him many marks of esteem and affection: but Tasso, fearing that the duke of Ferrara would require him to be delivered up, and that the duke of Savoy would choose rather to comply than forfeit the friendship of that prince, precipitately set out for Rome alone, and without proper necessaries for such a journey.

He got safe, however, to Rome; where he went directly to his friend Maurizio Cataneo, who received him with great kindness, and the whole city seemed to rejoice at the presence of so extraordinary a person. He was visited by princes, cardinals, prelates, and all the learned in general. But being impatient of exile, he took measures to make his peace with the duke, and succeeded.

The duke received him with great appearance of satisfaction, and gave him fresh marks of his esteem. But Tasso having made some attempts on the princess Leonora, whom he has celebrated in several of his verses, the duke her brother, believing, or pretending to believe, that his ill conduct proceeded from a disordered understanding, caused him to be strictly confined in the hospital of St Anne. Tasso applied to the duke, by every friend he had, to release him from this confinement; but the duke coldly answered, that

Tasso. instead of endeavouring to procure the enlargement of a person in his condition, they ought rather to exhort him to submit patiently to such remedies as were judged proper for him. Tasso was certainly disordered in his mind, whether as the effect or cause of this confinement: he was conscious that he laboured under some distemper, and he believed the cause of it to be supernatural, and fancied himself haunted by a spirit that continually disordered his books and papers; to which, however, the tricks played him by his keepers might contribute. He continued, notwithstanding, to solicit the interposition of all the powers in Italy, to whom he could find means to apply, particularly the emperor and the pope; but without success. At last, after he had been a prisoner seven years, Vincentio Gonzaga prince of Mantua came to Ferrara among other great personages, during the festivals and rejoicings that were held there on the marriage of Cæsar of Este with Virginia of Medicis, procured his liberty, and took him with him to Mantua, he being then in the 42d year of his age.

At Mantua he lived about a year in great favour with the prince, and in all the splendour and affluence which the favour of great princes confers: but he was weary of a state of dependence, however splendid and luxurious; and therefore resolved to go to Naples, and endeavour to recover his mother's jointure, which had been seized by her relations when he went into exile with his father Bernardo. With this view he procured letters of recommendation to the viceroy; and having taken leave of the prince of Mantua, he went first to Bergamo, where he staid some time, and from thence proceeded to Naples.

At Naples he immediately commenced a suit at law for the recovery of his right, and divided his time between a prosecution of that and his studies. But during the summer he retired to Bisaccio with one Giovanni Batista Manso, with whom he had contracted an intimate friendship.

Tasso, who was now in his 45th year, appeared to Manso, while they were at Bisaccio, to be affected with a melancholy, which had very singular effects; he therefore very frequently questioned him about them; and Tasso told him that he had a familiar spirit, with whom he frequently and freely conversed. Manso treated this as an illusion, but Tasso still affirmed it to be real; and telling him that the spirit would meet and converse with him the next day, invited him to be present. Manso coming at the hour appointed, saw Tasso fix his eyes with great earnestness upon a window, and perceiving him to continue without motion, he called him several times by his name. Tasso made no reply; but at length cried out with great vehemence, "There is the friendly spirit that is come to converse with me; look, and be convinced that what I have said is true." Manso looked, not without some surprise, but saw nothing except the sun beams which shone through the window. He was just going to ask where the pretended spirit was, when he was prevented by Tasso's speaking with great earnestness to some imaginary being, sometimes putting questions, and sometimes giving answers, in a manner so pleasing, and with such elevation of expression, that Manso had no desire to interrupt him: the conversation at last ended by the supposed departure of the spirit; when Tasso turning round to his friend, asked if his doubts were removed? To which he made no reply, being so much amazed that he gladly waved all farther conversation on the subject.

Finding his law-suit not likely to be soon determined, he went from Naples to Rome, where he continued about a year in high favour with Pope Sextus Quintus; and then went to Florence, at the pressing invitation of Ferdinando grand duke of Tuscany, who had been cardinal at Rome when Tasso first resided there.

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Having spent about another year at Florence, he returned again to Naples; and there applied himself to correct his *Jerusalem Delivered*. Soon after the publication of this work, Hippolito Aldrobandini succeeded Sextus Quintus to the papacy, by the name of *Clement the VIIIth*; and his two nephews, Cynthio and Pietro Aldrobandini, were created cardinals. Cynthio, who was a great patron of learning and genius, and had known Tasso when he last resided at Rome, prevailed with him once more to leave his retreat at Naples, and live with him in that city. Here he continued till his 50th year; and being then again weary of his situation, and desirous to prosecute his law-suit, he obtained permission to retire once more to Naples, where he took up his abode with the Benedictine fathers in the convent of St Severin. Cardinal Cynthio, however, found means to recal him again to Rome, after a very short absence, by having prevailed with the Pope to confer upon him the honour of being publicly and solemnly crowned with laurel in the Capitol.

He set out from Naples to receive this honour, with a preface that he should never return; and arrived at Rome in the beginning of the year 1595, being then about 51 years old: he was met at the entrance of the city by many prelates and persons of distinction, and was introduced by the two cardinals to the pope, who complimented him by saying, "That his merit would confer as much honour on the laurel he was about to receive, as the laurel had formerly conferred on others." Orders were immediately given to decorate not only the pope's palace and the Capitol, but all the principal streets through which the procession was to pass: but Tasso, whether from an habitual dejection of mind, or a secret sensation of the first approaches of a disease which he apprehended would be fatal, declared that all these pompous preparations would be in vain.

It happened, that while they were waiting for fair weather to celebrate the solemnity, cardinal Cynthio fell sick; and, before he was perfectly recovered, Tasso himself was taken ill, and died on the 15th day of his sickness, aged 51. His poems have acquired him an immortal reputation. The principal of them are, 1. *Jerusalem Delivered*. 2. *Jerusalem Conquered*. 3. *Rinaldo*. 4. *The Seven Days of the Creation*. 5. *The Tragedy of Torimond*. 6. *Aminta*, &c. All Tasso's works were printed together at Florence in 1724, in six volumes folio, with the pieces for and against his *Jerusalem Delivered*. A splendid edition of this last poem was printed at Venice in 1745, in folio. The best edition of Mirebaud's French translation is that of Paris in 1735, in two vols 12mo. His *Aminta* and *Gierusalemme Liberata* have been translated into English.

TASTE, a certain sensation, or class of sensations, excited in the mind by certain bodies, which are called *sapid*, applied to the tongue and palate, and moistened with the saliva. This is the original and proper meaning of the word *taste* (see *METAPHYSICS*, n° 46); but as the qualities of bodies which produce these sensations are unknown, they have in all languages got the names of the sensations themselves, by that figure of speech which substitutes the cause for the effect. Hence we talk of the tastes of sugar, wormwood, honey, vinegar, &c.; and say, that the taste of sugar is sweet and of vinegar sour. Tastes have been divided into simple and compound; and philosophers have to very little purpose endeavoured to ascertain the number of each species. Attempts have likewise been made to determine from their tastes the effects of different substances on the human body, taken into the stomach as food or physic; but by stating the results of the various inquiries, we should be more likely to mislead the unlearned reader, than to communicate useful information to readers of any description.

Whoever is desirous of information on the subject may consult *Phil. Transf.* N° 280, 299; and *Abercromb. Nov. Med. Clavis*.

TASTE is likewise used in a figurative sense, to denote that faculty of the mind by which we perceive and enjoy whatever is beautiful or sublime in the works of nature or of art. Like the taste of the palate, this faculty relishes some things, is disgusted with others, and to many is indifferent; and from these obvious analogies between it and the external sense it has obtained its name. It has likewise been called an internal *sense*, and by one philosopher * * Dr Husa a *reflex sense*; whilst others have considered it, not as a distinct faculty or sense, but as the joint exertion of perception and judgment in some cases, and as a play of the imagination in others.

To decide among these different opinions, it will be necessary to ascertain, if we can, what are the objects of this faculty; for we hardly think that every thing which is beautiful, either in nature or art, can with propriety be called an object of taste. *Scarlet, blue, green, and yellow*, are all beautiful colours, and a *cube* and a *sphere* are beautiful figures; but it does not appear to us, that a man could be said to have either a good or a bad taste for relishing the perception of a *scarlet* more than that of a *yellow* colour, or a *spherical* more than a *cubical* figure. A native of Africa considers thick lips and a flat nose as essential to female beauty; whilst the inhabitant of Europe prefers to all other forms of the nose that which is called *Grecian*, and is disgusted with lips either very thick or very thin. But upon what principles can we say that the African has a bad, and the European a good, taste?

With respect to the objects of the external sense, we are generally so constituted by nature as to relish, in the highest degree, those kinds of food which are most wholesome; and such a taste, which we believe is always found in infants, is justly said to be sound and uncorrupted. It is in the highest perfection too at first; for it depends not upon culture of any kind, and is incapable of improvement. The reverse of all this is the case with respect to internal taste; of which the variety is obvious to the most careless observer, and is found, on examination, to be still greater in reality than it is in appearance. Every voice is indeed united in applauding elegance, propriety, simplicity, spirit in writing; and in blaming sustin, affectation, coldness, and a false brilliancy: but when critics come to particulars, this seeming unanimity vanishes; and it is found that they had affixed very different meanings to the same expressions. Perhaps no man ever attentively beheld the rising or the setting sun without feeling some emotions of pleasure which filled his mind; or went for the first time into such a building as the cathedral church of York, without being struck with a pleasing, though solemn, reverence. Yet it is certain, that the emotions of the clown, however acute he may be by nature, and perfect in all his faculties, are not the same, at least in degree, with those of the poet or philosopher when contemplating the rising or setting sun; or of the scientific mechanic when viewing the structure of the pillars and roof of the Gothic cathedral. We are not indeed sure that the pleasure of the clown on these occasions rises above that of mere sensation. Any bright and beautiful object presented to the eye, gives a pleasing sensation to the mind, in consequence of that peculiar agitation which such objects communicate to the optic nerves and the brain; and to us it appears, that the clown feels nothing more than this from the view of the rising sun or the magnificent church. Perhaps he may compare the sensations which he feels on these occasions with others which he has formerly felt in some degree similar to them, and have his pleasure heightened by the exercise

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exercise of that faculty of which the province is to judge upon comparison; but we have no reason to suppose, that from the rising sun he receives any emotions different in kind from what he would receive from a blazing heath, were it accompanied with the same varying tints of colour; or that the church impresses on his fancy more than that wonder with which he would view any other building equally large and equally novel, though of a form very different. In poetry and painting the vulgar are always delighted with the melody of the verse and the brilliancy of the colours; and think of nothing else as beauties, either in the one or in the other, unless the painting be the picture of some known object, and the poem describe scenes or actions in which they may be selfishly interested. Hence it is that the vulgar are more captivated by the splendor of the Venetian style of painting, than by the simple grandeur of the Roman and Bolognian Schools; for the art of the former, which has been carried to the highest degree of perfection, is to give pleasure to the eye or the sense; that of the latter is to fill the imagination. The powers exerted in the former school Sir Joshua Reynolds calls the *language* of painters, which he compares to an *empty tale told by an idiot, full of sound and fury, signifying nothing*. The compositions of the latter schools may be compared to the sublimity of Milton's sentiments, which would be disgraced by those petty ornaments to which it leaves not the reader at leisure to attend.

If this be so, the pleasures which the vulgar derive from what are called objects of taste are merely gratifications of the senses; or if any of these objects ever interest their higher faculties, it must be by inspiring them with confidence or dread; confidence of their own safety, for instance, if the building which they admire appear to them to be stable; and dread, if they have formed of it a contrary opinion. Very different is the pleasure which the man of cultivated taste derives from the beauties either of nature or of art: when he beholds the rising or the setting sun, he has indeed the pleasing sensation, which is all that the rude man feels; but along with this arises in his imagination a train of ideas, which hurries him beyond the object before him to its beneficent effects and its Almighty Creator: and if he has been much conversant with the works of descriptive poets, a number of pleasing ideas treasured up in his memory will, by the principle of association, pass in review before him, though they be not connected either with one another, or with the rising or setting sun, by a relation so close as that of cause and effect. In like manner, when the scientific architect views the Gothic cathedral, he must admire its solemn magnificence, though with less wonder than it excites in the breast of the clown; but he feels an additional pleasure, derived from a source to which the other has no access. He perceives the many contrivances displayed in its structure for uniting stability with lightness; and from contemplating the building, he is instantly led by a natural train of thought to admire the skill of the builder.

The nature of any person's taste, therefore, is generally determined from the character of his imagination and the soundness of his judgment. When any object either of sublimity or beauty is presented to the mind, every man is conscious of a train of thought being immediately awakened in his imagination, analogous to the character or expression of the original object. The simple perception of the object we frequently find is insufficient to excite these emotions, unless it is accompanied with this operation of mind; unless, according to common expression, our imagination is seized, and our fancy busied in the pursuit of all those trains of thought which are allied to this character or expression.

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Thus, when we feel either the beauty or sublimity of natural scenery, the gay lustre of a morning in spring, or the mild radiance of a summer evening, the savage majesty of a wintry storm, or the wild magnificence of a tempestuous ocean, we are conscious of a variety of images in our minds, very different from those which the objects themselves can present to the eye. Trains of pleasing or of solemn thought arise spontaneously within our minds; our hearts swell with emotions, of which the objects before us seem to afford no adequate cause; and we are never so much satiated with delight, as when, in recalling our attention, we are unable to trace either the progress or the connection of those thoughts which have passed with so much rapidity through our imagination.

If the mind is in such a state as to prevent this freedom of imagination, the emotion, whether of sublimity or beauty, is unperceived. In so far as the beauties of art or nature affect the external senses, their effect is the same upon every man who is in possession of these senses. But to a man in pain or in grief, whose mind by these means is attentive only to one object or consideration, the same scene or the same form will produce no feeling of admiration, which, at other times, when his imagination was at liberty, would have produced it in its fullest perfection. It is upon the vacant and the unemployed, accordingly, that the objects of taste make the strongest impression. It is in such hours alone that we turn to the compositions of music or of poetry for amusement. The seasons of care, of grief, or of business, have other occupations, and destroy, for the time at least, our sensibility to the beautiful or the sublime, in the same proportion that they produce a state of mind unfavourable to the indulgence of imagination.

There are many objects of taste, however, which produce not their full effect on the imagination, but through the medium of the judgment. We have given one instance in architecture, and shall give another in sculpture. The beauty of the Farnese Hercules is one kind of beauty; that of the gladiator in the palace of Chigi another; and that of the Apollo of Belvedere a third. Each of these figures is acknowledged to be perfect in its kind; and yet Sir Joshua Reynolds affirms, that the highest perfection of the human figure is not to be found in any one of them, but in that form which might be taken from them all, and would partake equally of the activity of the gladiator, of the delicacy of the Apollo, and of the muscular strength of the Hercules. If the judgment of this eminent artist be admitted, the perfection of these statues cannot consist in any thing which is the immediate object of sense, either external or internal; but in something which, being perceived by the eye, is referred by the understanding to what we know of the characters of Hercules, Apollo, and the Gladiator, and which we believe it was the intention of the statuary to express. Nay, there are objects of which taste is sometimes said to judge, though they have little or no effect whatever on the imagination. A book of abstract science, written in a prolix and intricate style, might be said to be in a bad taste; and had Swift, in his clear and simple style, written *An Essay on the Human Understanding*, his work, supposing him master of the subject, would undoubtedly have displayed more taste than Locke's, in which the terms are sometimes vague, and the periods often incumbered. This is actually the case of Berkeley, whom every man admits to have been a writer of good taste, though neither *The Principles of Human Knowledge*, *The Dialogues on Matter*, nor the beautiful work intitled *The Minute Philosopher*, is capable of affording pleasure to the senses or the imagination. His beauty consists merely in the perspicuity of his style, of which the understanding alone is the judge. The metaphysical

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physical writings of Dr Reid possess in an eminent degree the same beauty; and no man of true taste can read them without admiring the elegant simplicity of the composition as much as the strength of the reasoning, and feeling from the whole a pleasure which the poetical style of Shaftesbury cannot communicate.

If this be a just account of the pleasures of taste, that faculty cannot be properly considered as a mere internal sense, since to its enjoyments a well-stored fancy is necessary in some cases, and the reasoning power in all; and the poet and the painter who wish to excel in their respective professions, must not content themselves, the one with filling the ear of the reader with mellifluous sounds, and the other with dazzling or deceiving the eye of the spectator by the brilliancy of his colours, but both must strive for fame by captivating the imagination; whilst the architect, who aspires to a similar celebrity, must make the purpose of his ornaments obvious to every person capable of judging. The landscapes of Claude Lorrain, the music of Handel, the poetry of Milton, excite feeble emotions in our minds, when our attention is confined to the qualities they present to our senses, or when it is to such qualities of their composition that we turn our regard. It is then only we feel the sublimity or beauty of their productions, when our imaginations are kindled by their power, when we lose ourselves amid the number of images that pass before our minds, and when we waken at last from this play of fancy as from the charm of a romantic dream.

* Discourse delivered at the Royal Academy, Dec. 14. 1770.

It is well observed by Sir Joshua Reynolds*, that taste is sometimes praised in such terms by orators and poets, who call it *inspiration*, and *a gift from heaven*, that though a student by such praise may have his attention roused, and a desire excited of obtaining this gift, he is more likely to be deterred than encouraged in the pursuit of his object. "He examines his own mind, and perceives *there* nothing of that divine inspiration with which he is told so many others have been favoured. He never travelled to heaven to gather new ideas; and he finds himself possessed of no other qualifications than what mere common observation and a plain understanding are able to confer. Thus he becomes gloomy amidst the splendour of figurative declamation, and thinks it hopeless to pursue an object which he supposes out of the reach of human industry. But on this, as on many other occasions, we ought to distinguish how much is to be given to enthusiasm, and how much to common sense; taking care not to lose in terms of vague admiration that solidity and truth of principle upon which alone we can reason." Whoever possesses the ordinary powers of perception, sensibility of heart, good sense, and an imagination capable of being roused by the striking objects of nature and of art, may, without inspiration, become, by mere experience, a man of fine taste in the objects of which he aspires to be a critical judge.

This being the case, we may easily account for the variety of tastes which prevail among men, not only as individuals but as nations. We have already mentioned the difference in one instance between the European taste and the African respecting female beauty; and we may now affirm, as we hope to prove our affirmation, that the one taste is equally correct with the other. The charms of female beauty exist not in the mere external form and colour considered by themselves (for then the inanimate statue of the Venus de Medicis would give more delight to the European beholder than the finest woman that ever lived); but we associate external beauty with sweetness of disposition, and with all the train of endearments which take place in the union of the sexes; and it is this association which delights the man of taste, as giving refinement to an appetite which in

itself is gross and sensual. A similar association must be formed in the breast of the African who has any taste; and as he never knew feminine softness, or any of the endearing qualities of the sex, but as united with thick lips, a flat nose, a black skin, and woolly hair—a sable beauty of that description must excite in his breast the same emotions that are excited in the breast of an European by the fair woman with Grecian features.

But is there not an ideal or perfect beauty of the human form? There certainly is, as of every other natural object; but it cannot be the same in Europe as in Africa, unless to a Being who is acquainted with all the peculiarities of form, national and individual, that are to be found among the inhabitants of the whole earth. It has been supposed, and we think completely proved, by one of the best writers that we have on the philosophy of taste*, that the sublimity or beauty of forms arises altogether from the associations we connect with them, or the qualities of which they are expressive to us. The qualities expressed by the male and female forms are very different; and we would by no means think the woman beautiful who should have the form of the Farnese Hercules, or admire the shapes of the hero who should be formed like the Venus de Medicis; because the proportions of such a woman would indicate strength and intrepidity, where we wish to find only gentleness and delicacy; and the delicate form of the hero would indicate softness and effeminacy, where the opposite qualities only can be esteemed. As we associate with the female form many desirable qualities, every woman is esteemed more or less beautiful as her figure and features indicate a greater or smaller number of these qualities; and the same is the case with respect to the qualities which adorn the male character, and the form and features by which they are expressed. Upon comparing a number of human beings with one another, we find, that with respect to every feature and limb, there is one central form to which nature always tends, though she be continually deviating from it on the right hand and on the left: (See NOSE). This form therefore is considered as the most perfect form of the species, and most expressive of the qualities for which that species is valued; but in Africa, the central form, with respect to the proportions of the human body and the features of the human face, is very different from what it is in Europe; and therefore the ideal or perfect beauty of the human form and features cannot be the same in both countries. No doubt, if a man could examine the limbs and features of every individual of the human race, he would discover one central form belonging to the whole, and be led to esteem it the standard of beauty; but as this is obviously impossible, the common idea or central form belonging to each great class of mankind must be esteemed the standard of beauty in that class, as indicating most completely the qualities for which individuals are esteemed. Thus there is a common form in childhood and a common form in age; each of which is the more perfect as it is the more remote from peculiarities: but though age and childhood have something in common, we should not deem the child beautiful who was formed exactly like the most handsome man, nor the man handsome who was formed exactly like the most beautiful child. This doctrine is well illustrated by Sir Joshua Reynolds*, who has applied it to every object esteemed beautiful in nature; and proved, that the superiority of Claude Lorrain over the landscape-painters of the Dutch and Flemish schools, arises chiefly from his having generalized his conceptions, and formed his pictures by compounding together the various draughts which he had previously made from various beautiful scenes and prospects. "On the whole (says he), it seems to me that there is but one presiding principle which regulates and

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gives stability to every art. The works, whether of poets, painters, moralists, or historians, which are built upon general nature, live for ever; while those which depend for their existence on particular customs and habits, a particular view of nature, or the fluctuation of fashion, can only be coeval with that which first raised them from obscurity. All the individual objects which are exhibited to our view by nature, upon close examination, will be found to have their blemishes and defects. The most beautiful forms have something about them like weakness, minuteness, or imperfection. But it is not every eye that perceives these blemishes: It must be an eye long used to the contemplation and comparison of these forms; which alone can discern what any set of objects of the same kind has in common, and what each wants in particular."

From these reasonings the same great artist concludes, that the man who is ambitious of the character of possessing a correct taste, ought to acquire a "habit of comparing and digesting his notions. He ought not to be wholly unacquainted with that part of philosophy which gives him an insight into human nature, and relates to the manners, characters, passions, and affections. He ought to know *something* concerning the *mind*, as well as a great deal concerning the *body*, and the various external works of nature and of art; for it is only the power of distinguishing right from wrong that is properly denominated *taste*."

"Genius and taste, in their common acceptation, appear to be very nearly related; the difference lies only in this, that genius has superadded to it a habit or power of execution. Or we may say, that taste, when this power is added, changes its name, and is called *genius*. They both, in the popular opinion, pretend to an entire exemption from the restraint of rules. It is supposed that their powers are intuitive; that under the name of *genius* great works are produced, and under the name of *taste* an exact judgment is given, without our knowing why, and without being under the least obligation to reason, precept, or experience."

"One can scarce state these opinions without exposing their absurdity; yet they are constantly in the mouths of men, and particularly of illiterate and affected connoisseurs. The natural appetite, or taste of the human mind, is for *truth*; whether that truth results from the real agreement or equality of original ideas among themselves, from the agreement of the representation of any object with the thing represented, or from the correspondence of the several parts of any arrangement with each other. It is the very same taste which relishes a demonstration in geometry, that is pleased with the resemblance of a picture to an original, and touched with the harmony of music."

"But besides *real*, there is also *apparent* truth, or opinion, or prejudice. With regard to real truth, when it is known, the taste which conforms to it is and must be uniform. With regard to the second sort of truth, which may be called *truth upon sufferance*, or *truth by courtesy*, it is not fixed but variable. However, whilst these opinions and prejudices on which it is founded continue, they operate as truth; and the art, whose office it is to please the mind as well as instruct it, must direct itself according to *opinion*, or it will not attain its end. In proportion as these prejudices are known to be generally diffused or long received, the taste which conforms to them approaches nearer to certainty, and to a sort of resemblance to real science, even where opinions are found to be no better than prejudices. And since they deserve, on account of their duration and extent, to be considered as really true, they become capable of no small degree of stability and determination by their permanent and uniform nature."

Taste,
Tate.

"Of the judgment which we make on the works of art, and the preference that we give to one class of art over another, if a reason be demanded, the question is perhaps evaded by answering, I judge from my taste; but it does not follow that a better answer cannot be given, though for common gazers this may be sufficient. Every man is not obliged to investigate the causes of his approbation or dislike. The arts would lie open for ever to caprice and casualty, if those who are to judge of their excellencies had no settled principles by which they are to regulate their decisions, and the merit or defect of performances were to be determined by unguided fancy. And indeed we may venture to assert, that whatever speculative knowledge is necessary to the artist, is equally and indispensably necessary to the critic and the connoisseur."

"The first idea that occurs in the consideration of what is fixed in art or in taste, is that presiding principle which we have already mentioned, the general idea of nature. The beginning, the middle, and the end of every thing that is valuable in taste, is comprised in the knowledge of what is truly nature; for whatever ideas are not conformable to those of nature or universal opinion, must be considered as more or less capricious; the idea of nature comprehending not only the forms which nature produces, but also the nature and internal fabric and organization, as I may call it, of the human mind and imagination. General ideas, beauty, or nature, are but different ways of expressing the same thing, whether we apply these terms to statues, poetry, or picture. Deformity is not nature, but an accidental deviation from her accustomed practice. This general idea therefore ought to be called *nature*; and nothing else, correctly speaking, has a right to that name. Hence it plainly appears, that as a work is conducted under the influence of general ideas, or partial, it is principally to be considered as the effect of a good or a bad taste."

Upon the whole, we may conclude that the real substance, as it may be called, of what goes under the name of *taste*, is fixed and established in the nature of things; that there are certain and regular causes by which the imagination and passions of men are affected; and that the knowledge of these causes is acquired by a laborious and diligent investigation of nature, and by the same slow progress as wisdom or knowledge of every kind, however instantaneous its operations may appear when thus acquired. A man of real taste is always a man of judgment in other respects; and those inventions which either disdain or shrink from reason, are generally more like the dreams of a disordered brain than the exalted enthusiasm of a sound and true genius. In the midst of the highest flights of fancy or imagination, reason ought to preside from first to last; and he who shall decide on the beauties of any one of the fine arts by an imaginary innate sense or feeling, will make as ridiculous an appearance as the connoisseur mentioned by Dr Moör, who praised as a work of the divine Raphael the wretched daubing by a Swiss copyist. The reader who wishes for further instruction in the philosophy of taste, may consult Gerard's Essay on Taste, with the dissertations of Voltaire, d'Alembert, and Montesquieu; Dr Blair's Lectures on the Belles Lettres; Dr Reid's Essays on the Intellectual Powers of Man; Alison's Essays on the Nature and Principles of Taste; and Sir Joshua Reynold's Discourses delivered in the Royal Academy."

TATE (Nahum), an English poet, born about the middle of the reign of Charles II. in Ireland, where he received his education. He was made poet-laureat to King William upon the death of Shadwell, and held that place until the reign of George I. whose first birth-day ode he lived

Tatian lived to write, and executed it with unusual spirit. He died in the mint in 1716, and was succeeded in the laurel by Mr Eusden. He was the author of nine dramatic performances, a great number of poems, and a version of the Psalms in conjunction with Dr Nicholas Brady.

TATIAN, a writer of the primitive church in the second century. He was born in Assyria, and trained up in the heathen religion and learning. Coming over to Christianity, he became the disciple of Justin Martyr, whom he attended to Rome. While Justin lived, he continued steadily orthodox: but after Justin's death he made a schism, and became the author of a new sect, condemning marriage, enjoining abstinence from wine and animal-food, and suffering only water to be used in the holy mysteries; whence his followers were called *Encratites* and *Hydroparastates*. None of his works are now extant but his piece against the Gentiles; or, as it is usually intitled, his *Oration to the Greeks*.

TATIUS (Achilles), a native of Alexandria, was the author of a book on the sphere, which father Petau translated into Latin. There is also attributed to him a Greek romance on the loves of Leucippe and Clitophon, of which Salmasius has given a beautiful edition in Greek and Latin, with notes. Suidas says, that this Achilles Tatius was a Pagan, but that he afterwards embraced the Christian religion, and became a bishop. Photius mentions him in his *Bibliotheca*.

TATONNEUR, in zoology. See **LEMUR**.

TATTOOING, or **TATTOWING**, an operation in use among the islanders in the South Sea for marking their bodies with figures of various kinds which they consider as ornamental. It is performed by puncturing the skin, and rubbing a black colour into the wounds. The instrument used somewhat resembles a comb, the teeth of which are repeatedly struck into the skin by means of a small mallet. It is very painful; but the children are forced by their relations to submit to it.

TATTOU, a beat of a drum at night to advertise the soldiers to retreat, or repair to their quarters in the garrison, or to their tents in a camp.

TAVERNIER (John Baptist), a famous French traveller, was born in 1605. In the course of 40 years he travelled six times to Turkey, Persia, and the East Indies, and visited all the countries in Europe, travelling mostly on foot. His travels have been frequently reprinted in six vols 12mo. He died on his seventh journey to the east, at Moscow, in 1699.

TAVIRA, or **TAVILA**, a considerable town of Portugal, and capital of the province of Algarve, with a handsome castle, and one of the best harbours in the kingdom, defended by a fort. It is seated in a pleasant fertile country, at the mouth of the river Gilaon, between Cape Vincent and the Strait of Gibraltar, 100 miles west by north of Cadiz. W. Long. 7. 46. N. Lat. 37. 18.

TAVISTOCK, a town of Devonshire in England, situated on the river Tavey or Tave, W. Long. 4. 12. N. Lat. 50. 37. It sends two members to parliament, and gives the title of *marquis* to the noble family of Russell duke of Bedford.

TAUNTON, a large, elegant, and well built town of Somersetshire, 146 miles from London. It consists principally of four streets paved and lighted; the market-place is spacious, and has a handsome market-house, with a town hall over it, which was finished in 1773. It has an extensive woollen manufactory; and in 1780 a silk manufactory was introduced. Its castle, the ruins of which remain, was in 1645 defended for the parliament by colonel Blake against an army of 10,000 men under lord Goring, but was dismantled by Charles II. In 1685 the duke of Monmouth

made this place his head-quarters. Its church, which is large and beautiful, is a fine specimen of the florid Gothic style of architecture. The tower, which is lofty, is of excellent workmanship, crowned at the top with four stately pinnacles, 32 feet high. The whole perhaps is not equalled in the kingdom. Taunton is pleasantly seated on the river Tone, which is navigable to Bridgewater; is reckoned the best town in the county; and sends two members to parliament. W. Long. 3. 17. N. Lat. 50. 59.

TAURIS, or **TEBRIS**, a town of Persia, and capital of Aderbeitzan. It was formerly the capital of Persia, and is now the most considerable next to Isfahan; for it contains 15,000 houses, besides many separate shops, and about 200,000 inhabitants. It is about five miles in circumference, and carries on a prodigious trade in cotton, cloth, silks, gold and silver brocades, fine turbans, and shagreen leather. There are 300 caravanferas, and 250 mosques. Some travellers suppose it to be the ancient Ecbatana; but of this there is no certainty. It is seated in a delightful plain, surrounded with mountains, from whence a stream issues, which runs through the city. E. Long. 47. 50. N. Lat. 38. 18.

TAURUS, a great chain of mountains in Asia, which begin at the eastern part of Little Carimania, and extend very far into the India. In different places they have different names.

TAURUS, in astronomy, one of the 12 signs of the zodiac.

TAUTOLOGY, a needless repeating of the same thing in different words.

TAWING, the art of dressing skins in white, so as to be fit for divers manufactures, particularly gloves, &c.

All skins may be tawed; but those chiefly used for this purpose are lamb, sheep, kid, and goat skins.

The method of tawing is this: Having cleared the skins of wool or hair by means of lime, they are laid in a large vatt of wood or stone, set on the ground full of water, in which quicklime has been slacked; wherein they are allowed to lie a month or six weeks, according as the weather is more or less hot, or as the skins are required to be more or less soft and pliant.

While they are in the vatt, the water and lime is changed twice, and the skins are taken out and put in again every day: and when they are taken out for the last time, they are laid all night to soak in a running water, to get out the greatest part of the lime; and in the morning are laid together by sixes one upon another, upon a wooden leg, and are scraped stoutly one after another, to get the flesh off from the fleshy side, with a cutting two-handled instrument called a *knife*; and then they cut off the legs (if they are not cut off before) and other superfluous parts about the extremes. Then they are laid in a vatt or pit with a little water, where they are filled with wooden pestles for the space of a quarter of an hour; and then the vatt is filled up with water, and they are rinsed in it.

In the next place, they are thrown on a clean pavement to drain, and afterwards cast into a fresh pit of water, out of which they rinse them well, and are laid again on the wooden leg, six at a time, with the hair side outermost: over which they rub a kind of whetstone very briskly, to soften and fit them to receive four or five more preparations, given them on the leg both on the flesh-side and the hair-side, with the knife, after the manner above mentioned.

After this they are put into a pit of water and wheaten-bran, and stirred about in it with wooden poles, till the bran is perceived to stick to them, and then they are left: as they rise of themselves to the top of the water by a kind of fermentation, they are plunged down again to the bottom; and at the same time fire is set to the liquor, which burns as

Tawing, easily as if it were brandy, but goes out the moment the skins are all covered.

They repeat this operation as often as the skins rise above the water; and when they have done rising they take them out, lay them on the wooden leg, the fleshy side outwards, and pass the knife over them to scrape off the bran.

Having thus cleared them of the bran, they lay the skins in a large basket, and load them with huge stones to promote their draining: and when they have drained sufficiently, they give them their feeding; which is performed after the manner following:

For 100 of large sheep skins, and for smaller in proportion, they take eight pounds of alum and three of sea-salt, and melt the whole with water in a vessel over the fire, pouring the solution out, while yet lukewarm, into a kind of trough, in which is twenty pounds of the finest wheat-flower, with the yolks of eight dozen of eggs; of all which is formed a kind of paste, a little thicker than children's pap; which, when done, is put into another vessel, to be used in the following manner.

They pour a quantity of hot water into the trough in which the paste was prepared, mixing two spoonfuls of the paste with it; to do which they use a wooden spoon, which contains just as much as is required for a dozen of skins: and when the whole is well diluted, two dozen of the skins are plunged into it; but they take care that the water be not too hot, which would spoil the paste and burn the skins.

After they have lain some time in the trough they take them out, one after another, with the hand, and stretch them out; this they do twice: and after they have given them all their paste, they put them into tubs, and there tuck them afresh with wooden pestles.

Then they put them into a vatt, where they are suffered to lie for five or six days, or more; then they take them out in fair weather, and hang them to dry on cords or racks: and the quicker they are dried the better; for if they be too long a-drying, the salt and alum within them are apt to make them rise in a grain, which is an essential fault in this kind of dressing.

When the skins are dry, they are made up into bundles, and just dipt in fair water, and taken out and drained: they are then thrown into an empty tub; and after having lain some time are taken out and trampled under foot.

Then they draw them over a flat iron instrument, the top of which is round like a battledore, and the bottom fixed into a wooden block, to stretch and open them; and having been opened, they are hung in the air upon cords to dry; and being dry, they are opened a second time, by passing them again over the same instrument.

In the last place, they are laid on a table, pulled out, and laid smooth, and are then fit for sale.

TAX (*Taxa*, from the Greek *ταξις*, i. e. *ordo*, *tributum*), a tribute or imposition laid upon the subject for the support of government. See REVENUE.

It is the ancient indisputable privilege and right of the house of commons, that all grants of subsidies or parliamentary aids do begin in their house, and are first bestowed by them; although their grants are not effectual to all intents and purposes until they have the assent of the other two branches of the legislature. See COMMONS. The general reason given for this exclusive privilege of the house of commons is, that the supplies are raised upon the body of the people, and therefore it is proper that they alone should have the right of taxing themselves. This reason would be unanswerable, if the commons taxed none but themselves: but it is notorious, that a very large share of property is in the

possession of the house of lords; that this property is equally taxable, and taxed, as the property of the commons; and therefore the commons, not being the sole persons taxed, this cannot be the reason of their having the sole right of raising and modelling the supply. The true reason, arising from the spirit of our constitution, seems to be this. The lords being a permanent hereditary body, created at pleasure by the king, are supposed more liable to be influenced by the crown, and when once influenced to continue so, than the commons, who are a temporary elective body, freely nominated by the people. It would therefore be extremely dangerous to give the lords any power of framing new taxes for the subject; it is sufficient that they have a power of rejecting, if they think the commons too lavish or improvident in their grants. But so reasonably jealous are the commons of this valuable privilege, that herein they will not suffer the other house to exert any power but that of rejecting. They will not permit the least alteration or amendment to be made by the lords to the mode of taxing the people by a money-bill: under which appellation are included all bills by which money is directed to be raised upon the subject, for any purpose or in any shape whatsoever; either for the exigencies of government, and collected from the kingdom in general, as the land-tax; or for private benefit, and collected in any particular district, as by turnpikes, parish-rates, and the like. Yet Sir Matthew Hale mentions one case, founded on the practice of parliament in the reign of Henry VI. wherein he thinks the lords may alter a money-bill: and that is, if the commons grant a tax, as that of tonnage and poundage, for four years; and the lords alter it to a less time, as for two years: here, he says, the bill need not be sent back to the commons for their concurrence, but may receive the royal assent without farther ceremony; for the alteration of the lords is consistent with the grant of the commons. But such an experiment will hardly be repeated by the lords, under the present improved idea of the privilege of the house of commons; and, in any case where a money bill is remanded to the commons, all amendments in the mode of taxation are sure to be rejected.

The commons, when they have voted a supply to his majesty, and settled the *quantum* of that supply, usually resolve themselves into what is called a *committee of ways and means*, to consider the ways and means of raising the supply so voted. And in this committee every member (though it is looked upon as the peculiar province of the chancellor of the exchequer) may propose such scheme of taxation as he thinks will be least detrimental to the public. The resolutions of this committee (when approved by a vote of the house) are in general esteemed to be (as it were) final and conclusive. For though the supply cannot be actually raised upon the subject till directed by an act of the whole parliament, yet no monied man will scruple to advance to the government any quantity of ready cash, on the credit of a bare vote of the house of commons, though no law be yet passed to establish it.

The taxes which are raised upon the subject are either annual or perpetual.

I The usual annual taxes are those upon land and malt. See LAND and MALT.

II. The perpetual are, 1. The customs. 2. The excise-duty. 3. The salt-duty. 4. The post-office. 5. The stamp-duty. 6. House and window duty. 7. The duty on hackney-coaches and chairs. 8. That on offices and pensions.—See the articles CUSTOMS, EXCISE, POST, STAMP, HOUSE, HACKNEY, and OFFICES and PENSIONS.

As to the application of all these, see the articles REVENUE, NATIONAL DEBT, FUNDS, and CIVIL LIST.

Taxation,
Taxus

Tay.

TAXATION. See REVENUE, TAX, and FEUDAL System.
TAXUS, the YEW TREE, in botany: A genus of plants belonging to the class of *diœcia*, and order of *monodelphia*; and in the natural system ranging under the 51st order, *Coniferae*. The male calyx is triphyllous, gemmaceous, and imbricated: there is no corolla; the stamina are numerous; the antheræ peltated and octofid. The female calyx resembles the male; there is no corolla nor style, and only one seed with a calycle resembling a berry very entire. There are only two species mentioned by Linnæus, the *baccata* and *nucifera*. M. Sonnerat has added a third, called *capensis*; and Sir Charles Thunberg has inserted two more, the *macrophylla* and *verticellata*, in his *Flora Japonica*.

The *baccata*, or common yew tree, is a native of Britain, France, Switzerland, &c. and of North America. It is distinguished from the other species by linear leaves which grow very close, and by the receptacles of the male flowers being subglobose. The wood is reddish, full of veins, and flexible, very hard and smooth, and almost incorruptible. Its hardness renders it very proper for turners and cabinet-makers. It produces berries which are red, mucilaginous, and have a sweet mawkish taste. They are often eaten by birds, and are therefore not poisonous: But it is a common opinion that the leaves are poisonous to cattle, and many facts are mentioned of horses and cows having died by eating them. Others, however, deny these facts. It is found in several parts of the Highlands of Scotland in a wild state. At Glenlure, near Glen-Creran, in Upper Lorn, are the remains of an old wood of it. The place takes its name from the trees which grow in it; for *Glenlure* in the Gaelic language is no other than a corruption of *Gleanluir*, i. e. "The valley of yew trees." It is of no great height, but the trunk grows to a large size. Mr Pennant has taken notice of a very remarkable decayed one in Fortingal church-yard, the remains of which measured 56 feet and an half in circumference.

The yew is at present almost peculiar to church-yards; hence some naturalists suspect that it is an exotic. Several reasons have been assigned for its frequency in church-yards. The first is, that before the invention of gunpowder the warrior might never be at a loss for a bow. This is an opinion for which we have found no historical evidence: and till some be produced it is considered merely as a conjecture. There are several laws enacted by our forefathers for encouraging archery, but none of them mention the cultivation of the yew. The bows used in England were indeed made frequently of yew, but it was yew of foreign growth. In the reign of Elizabeth, a bow of the best foreign yew sold for 6s. 8d. while one made of English yew sold only for 2s. In 12 Edw. IV. it was ordained that every foreign merchant that should convey any goods from any country from which bow-staves had formerly been brought to this country, should for every ton of goods bring four bow-staves. A similar law was framed in the time of Richard III. It appears therefore that the church-yards did not supply the nation with bows.

A second opinion concerning the introduction of yew trees into church-yards is, that they were intended to defend the church against storms. But there are many other trees that would have answered this purpose much better; for the yew is of so slow a growth, that it would be long before it could be of any service at all, and is so low that it could never be a sufficient shelter. A third opinion is, that being an evergreen, it is an emblem of immortality. This is a pretty idea; but the misfortune is, that yew is always considered as a tree of baleful influence. This opinion is as old as Statius, who says, *metuenda succo taxus*. A fourth

opinion is, that when anciently it was the custom, as it still is in Catholic countries, to carry palms on Palm-Sunday, the yew was substituted on such occasions for the palm. Two or three trees, the usual number growing in church-yards, were sufficient for such purposes. This is the only opinion which receives any countenance from history. The following extract from Caxton's Direction for keeping Feasts all the Year, printed in 1483, will probably be considered as decisive on this subject. It is taken out of the lecture for Palm-Sunday; where the writer, after giving the scriptural account of our Saviour's triumphant entrance into Jerusalem, proceeds thus: "Wherefore holy churche this day makyth solempne processyon, in mynd of the processyon that Cryst made this day. But for encheson that we have non olyue that berith grene leef, algate therefore *we take ewe in ftede of palme and olyue*, and beren about in processyon, and so is thys day callyd *Palme Sondag*." As a confirmation of this fact, we may add, that the yews in the church-yards of East Kent are at this day called *palms*.

TAY, called by the Romans *Tavus* or *Taus*, the largest river in Scotland. It rises in Braidalbane, on the frontiers of Lorn; and having in the passage of a few miles augmented its stream by the accession of several small rills, spreads itself into a lake called *Loch Dochart*; out of which having run but a little space, it expands itself again. Leaving this second lake, it rolls some miles with a considerable body of water, and then diffuses itself abroad in the spacious Loch Tay; which, reckoning from the sources of the river, is 24 miles in length, though, strictly speaking, the lake is but 13: almost as soon as it issues from hence, it receives the river Lyon, coming out of Loch Lyon, and running through Glen Lyon; which, having travelled in a manner parallel to it, from its source, for a space of 25 miles, at length joins the Tay as it enters Athol, which it next traverses, and, directing its course in a manner due east, receives almost all the waters of that country. Bending then to the south, at the distance of six miles, it reaches Dunkeld; which, in the language of our ancestors, signifies "the hill of hazels," was the very centre of the old Caledonia, and is at present esteemed the heart of the Highlands. The river is very broad here, insomuch that there is a ferry-boat over it at each end of the town. Declining still to the south-east, with a winding course, for above 12 miles, the Tay receives a large supply of waters from the county of Angus; and then running south-west for eight miles more, is joined in that space by several rivers, the most considerable of which is the Almond. Turning then to the south east, at the distance of about three miles, this copious river comes with a swelling stream to Perth, or St Johnston's, which is the capital of the shire of that name.

The Tay, continuing still a south-east course, receives, a few miles below Perth, the river Erne; which, issuing from a loch of the same name, traverses the county of Strathern, and passes by Abernethy, once the capital of the Pictish kingdom; swelled by the waters of this last river, the Tay, running next directly east, enlarges itself till it becomes about three miles broad; but contracts again before the town of Dundee; soon after which it opens into the German ocean. At the entrance of the frith, there are sands both on the north and on the south side: the former styled *Goa*, the latter *Aberlay* and *Drumlan*; and before these, in the very mouth of the frith, those which are called the *Cross Sands*. At Buttonness, which is the northern promontory, there are two light-houses. The space between the north and the south sands may be near a mile, with about three fathoms water; but being within the frith, it grows deeper, and in the road of Dundee is full six fathoms. The frith of

Taylor. of Tay is not indeed so large or so commodious as that of Forth, but from Buttonness to Perth it is not less than 40 miles; and the whole may be, without any great impropriety, styled a harbour, which has Fife on one side, and the shires of Perth and Angus on the other, both very fertile and pleasant countries.

TAYLOR (Dr Jeremy), bishop of Down and Connor in Ireland, was the son of a barber at Cambridge, and there had his education. Upon entering into orders, he became divinity lecturer of St Paul's in London; and was, by the interest of archbishop Laud, elected fellow of All soul's college, Cambridge, in 1636. Two years after he became one of the chaplains of the archbishop, who bestowed on him the rectory of Uppingham in Rutlandshire. In 1642 he was chaplain to the king; and a frequent preacher before him and the court at Oxford. He afterward attended in the king's army in the condition of a chaplain. Upon the declining of his majesty's cause, he retired into Wales, where he was permitted to officiate as minister, and to keep a school, in order to maintain himself and his children. In this retirement he wrote several of his works. Having spent several years there, his family was visited with sickness; and he lost three sons of great hopes within the space of two or three months. This affliction touched him so sensibly, that it made him desirous to leave the country; and, going to London, he for a time officiated in a private congregation of loyalists to his great hazard. At length meeting with Edward lord Conway, that nobleman carried him over with him into Ireland, and settled him at Portmore, where he wrote his *Ductor Dubitantium*. Upon the Restoration he returned to England; soon after, he was advanced to the bishopric of Down and Connor in Ireland; and had the administration of the see of Dromore granted to him. He was likewise made privy-counsellor and vice-chancellor of the university of Dublin; which place he held till his death. He died of a fever at Lisnegarvy in 1667, and was interred in a chapel which he himself had built on the ruins of the old cathedral of Dromore.

TAYLOR (Dr Brook), was born at Edmonton, August 18th 1685. He was the son of John Taylor, Esq; of Bifron's-house in Kent, by Olivia, daughter of Sir Nicholas Tempelt, of Durham, Baronet. His grandfather, Nathaniel Taylor, was one of those puritans whom "Cromwell thought fit to elect by a letter, dated June 14th 1653, to represent the county of Bedford in parliament." The character of his father partook in no small degree of the austerity that had been transmitted to him in the line of his ancestors, and by the spirit of the times in which they lived; and to this cause may be ascribed the disaffection which sometimes subsisted between the father and even such a son as is the subject of this article. The old gentleman's morose temper, however, yielded to the powers of music; and the most eminent professors of the art in that period were hospitably welcomed in his house. His son Brook was induced, by his natural genius, and by the disposition of his father, which he wished by all the means in his power to conciliate, to direct his particular attention to music; and he became in very early life a distinguished proficient in it.—"In a large family-piece, he is represented at the age of 13 sitting in the centre of his brothers and sisters; the two elder of whom, Olivia and Mary, crown him with laurel, bearing the insignia of harmony."

To music he added another accomplishment, in which he equally excelled. "His drawings and paintings, of which some are still preserved, require not those allowances for error or imperfection with which we scan the performances of even the superior *dilettanti*:—they will bear the test of scrutiny and criticism from artists themselves, and those of the

first genius and professional abilities." Though he was eminent in the culture and practice both of music and drawing in his early youth, his whole attention was not occupied by these fascinating arts. His classical education was conducted at home under a private tutor; and his proficiency in the ordinary branches of the languages and the mathematics was so great, that he was deemed-qualified for the university at the early age of 15.

In 1701 he was entered a Fellow Commoner of St John's College, Cambridge. At that period mathematics engaged more particularly the attention of the university; and the examples of eminence in the learned world, derived from that branch of science, attracted the notice and roused the emulation of every youth possessed of talents and of application. We may presume, that Brook Taylor, from the very hour of his admission at college, adopted the course of study which a Machin, a Keil, and, above all, a Newton, had opened to the mind of man, as leading to discoveries of the celestial system.—That he applied early to these studies, and without remission, is to be inferred from the early notice and kind attention with which he was honoured by those eminent persons, and from the extraordinary progress which he made in their favourite science.

In 1708 he wrote his treatise On the Centre of Oscillation, which was not published in the Philosophical Transactions till some years afterwards. In 1709, he took his degree of Bachelor of Laws. In 1712, he was chosen a Fellow of the Royal Society. During the interval between these two periods, he corresponded with Professor Keil on several of the most abstruse subjects of mathematical disquisition. Sir William Young informs us, that he has in his possession a letter, dated in 1712, addressed to Mr Machin, which contains at length a solution of Kepler's problem, and marking the use to be derived from that solution. In this year he presented to the Royal Society three different papers: one On the Ascent of Water between two Glass Planes; a second, On the Centre of Oscillation; and a third, On the Motion of a stretched String. It appears from his correspondence with Keil, that in 1713 he presented a paper on his favourite subject of Music: but this is not preserved in the Transactions.

His distinguished proficiency in those branches of science, which engaged the particular attention of the Royal Society at this period, and which embroiled them in contests with foreign academies, recommended him to the notice of its most illustrious members; and in 1714 he was elected to the office of secretary. In this year he took at Cambridge his degree of Doctor of Laws; and at this time he transmitted, in a letter to Sir Hans Sloane, An Account of some curious Experiments relative to Magnetism; which, however, was not delivered to the Society till many years afterward, when it was printed in the Transactions. His application to those studies to which his genius inclined was indefatigable: for we find that in 1715 he published in Latin his *Methodus Incrementorum*; also a curious essay preserved in the Philosophical Transactions, entitled An Account of an Experiment for the Discovery of the Laws of Magnetic Attraction; likewise a treatise well known to mathematicians, and highly valued by the best judges, On the Principles of Linear Perspective. In the same year (such were his admirable talents, and so capable were they of being directed to various subjects), he conducted a controversial correspondence with the Count Raymond de Montmort, on the Tenets of Malebranche; which occasioned his being particularly noticed in the eulogium pronounced by the French academy on the decease of that eminent metaphysician.

The new philosophy of Newton (as it was then called)

Taylor. engaged the attention of mathematicians and philosophers both at home and abroad. At Paris it was in high estimation; and the men of science in that city were desirous of obtaining a personal acquaintance with the learned secretary of the Royal Society, whose reputation was so generally acknowledged, and who had particularly distinguished himself in the Leibnitzian or German controversy, as we may denominate it, of that period. In consequence of many urgent invitations, he determined to visit his friends at Paris in the year 1716. He was received with every possible token of affection and respect; and had an opportunity of displaying many traits of character, which mark the general scholar and accomplished gentleman, as well as the profound mathematician. His company was courted by all "who had temper to enjoy, or talents to improve, the charms of social intercourse." Besides the mathematicians, to whom he had always free access, he was here introduced to Lord Bolingbroke, the Count de Caylus, and Bishop Bossuet. "He inspired partiality on his first address; he gained imperceptibly on acquaintance; and the favourable impressions which he made from genius and accomplishments, he fixed in further intimacy by the fundamental qualities of benevolence and integrity."

Among the ladies who honoured Dr Brook Taylor with a particular regard, we may mention the names of Marcilly de Villette, and of Miss Brunton, the beautiful and accomplished niece of Sir Isaac Newton.

Early in 1717 he returned to London, and composed three treatises, which were presented to the Royal Society, and published in the 30th volume of the Transactions. About this time his intense application had impaired his health to a considerable degree; and he was under the necessity of repairing, for relaxation and relief, to Aix-la-Chapelle. Having likewise a desire of directing his attention to subjects of moral and religious speculation, he resigned his office of secretary to the Royal Society in 1718.

After his return to England in 1719, he applied to subjects of a very different kind from those that had employed the thoughts and labours of his more early life. Among his papers of this date, Sir William Young has found detached parts of A Treatise on the Jewish Sacrifices, and a dissertation of considerable length On the Lawfulness of eating Blood. He did not, however, wholly neglect his former subjects of study, but employed his leisure hours in combining science and art; with this view he revised and improved his treatise on Linear Perspective. Drawing continued to be his favourite amusement to his latest hour; and it is not improbable, that his valuable life was shortened by the sedentary habits which this amusement, succeeding his severer studies, occasioned.

"He drew figures with extraordinary precision and beauty of pencil. Landscape was yet his favourite branch of design. His original landscapes are mostly painted in water colours, but with all the richness and strength of oils. They have a force of colour, a freedom of touch, a varied disposition of planes of distance, and a learned use of aerial as well as linear perspective, which all professional men who have seen these paintings have admired. Some pieces are compositions; some are drawn from nature; and the general characteristic of their effect may be exemplified, in supposing the bold foregrounds of Salvator Rosa to be backed by the succession of distances, and mellowed by the sober harmony, which distinguish the productions of Gaspar Poussin. The small figures interspersed in the landscapes would not have disgraced the pencil of the correct and classic Nicholas."

The work of Dr Brook Taylor in linear perspective was censured by Bernoulli, in a treatise published in the *Acta*

of Leipzig, as "abstruse to all, and as unintelligible to artists for whom it was more especially written." It must be acknowledged that this excellent work, for so it deserves to be called, was not level to the apprehensions of practitioners in the art of drawing and design: but it was much esteemed by mathematicians. Three editions of it have been published; and as it is now scarce, a republication of it in its most improved and perfect state would be very acceptable. Mr Kirby, however, has made it more plain and popular, in his treatise entitled "Brook Taylor's Perspective made easy;" and this book, detailing and illustrating the principles of the original work, has been the *vade mecum* of artists. Dr Brook Taylor was incensed by the invidious attacks of Bernoulli; and he published An Apology against J. Bernoulli's Objections, which may be seen in the 30th volume of the Philosophical Transactions. Bernoulli, with his usual envy of British mathematicians, had disputed our author's right to his own work. We have no reason to doubt Dr Taylor's claims to the undecided discovery of the method which he describes, though he is not an original inventor. This method was long before published by Guido Ubbaldi, in his Perspective, printed at Pesaro in 1600; where it is delivered very clearly, and confirmed by most elegant demonstrations; and where it is actually applied to the art of delineating the scenes of a theatre.

Toward the end of the year 1720, Dr Brook Taylor accepted the invitation of Lord Bolingbroke to spend some time at La Source, a country-seat near Orleans, which he held in right of his wife, the widow of the Marquis de Villette, nephew of Madame de Maintenon. During his residence at this beautiful spot, he fixed and cemented a friendship with its noble owners which terminated only with life.

In the next year he returned to England, and published the last paper which appears with his name in the Philosophical Transactions, entitled, An Experiment made to ascertain the Proportion of Expansion of Liquor in the Thermometer, with regard to the degree of Heat.

In 1721, Dr Brook Taylor married Miss Bridges of Wallington in the county of Surry, a young lady of good family, but of small fortune; and this marriage occasioned a rupture with his father, whose consent he had never obtained. The death of this lady in 1725, and that of an infant son, whom the parents regarded as the presage and pledge of reconciliation with the father, and who actually proved such, deeply affected the sensibility of Dr Taylor. However, during the two succeeding years he resided with his father at Bifrons, where "the musical parties, so agreeable to his taste and early proficiency, and the affectionate attentions of a numerous family welcoming an amiable brother, so long estranged by paternal resentment, not only soothed his sorrows, but ultimately engaged him to a scene of country retirement, and domesticated and fixed his habits of life. He could no more recur to the desultory resources and cold solace of society, which casual visits, slight acquaintance, and distant friendships, afford the man—who hath none to make, and cheer a constant home."

In 1725 he formed a new connection; and with the full approbation of his father and family, married Sabetta, daughter of John Sawbridge, Esq; of Olantigh, in Kent. In 1729, on the death of his father, he succeeded to the family estate of Bifrons. In the following year he lost his wife in child-bed. The daughter whose birth occasioned this melancholy event survived, and became the mother of Sir William Young, to whom we owe these memoirs of his grandfather.

In the interval that elapsed between the years 1721 and 1730, no production by Brook Taylor appears in the Philosophical

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losophical Transactions; nor did he publish in the course of that time any work. His biographer has found no traces of his learned labour, excepting a Treatise of Logarithms, which was committed to his friend Lord Paisley (afterward Abercorn), in order to be prepared for the press; but which probably was never printed. His health was now much impaired; relaxation became necessary, and he was diverted by new connections from the habit of severe study, which had distinguished the early period of his life, and which had contributed to contract the duration of it. Happy in the social circle of domestic enjoyment, and devoting his attention to business or amusement as they occurred, his application and his literary emulation seem to have declined. He did not long survive the loss of his second wife; and his remaining days were days of increasing imbecillity and sorrow.

"The essay entitled *Contemplatio Philosophica*, published by Sir William Young, 1793, appears to have been written about this time, and probably with a view to abstract his mind from painful recollections and regret. It was the effort of a strong mind, and is a most remarkable example of the close logic of the mathematician applied to metaphysics. But the blow was too deep at heart for study to afford more than temporary relief. The very resource was hurtful, and intense study but accelerated the decline of his health. His friends offered every comfort; in particular Lord Bolingbroke pressed his consolation, and sought to call his mind from regret of domestic endearments to social friendship at Dawley.

The attention and kindness of his friends, however, could not ward off the approaches of dissolution. "Having survived his second wife little more than a year, Dr Brook Taylor died of a decline in the 46th year of his age, December the 29th 1731, and was buried in the church-yard of St Ann's, Soho. I am spared (says his descendant) the necessity of closing this biographical sketch with a prolix detail of his character: in the best acceptance of duties relative to each situation of life in which he was engaged, his own writings, and the writings of those who best knew him, prove him to have been the finished Christian, gentleman, and scholar."

TAYLOR (Dr John), a learned dissenting minister, born in Lancashire. He settled first at Kirkstead in Lincolnshire, where he preached to a small congregation, and taught a grammar-school for near 20 years. Afterward he removed to Norwich, where he preached many years in great repute, until he was invited to superintend the academy formed at Warrington in Lancashire: but a few idle differences on formal punctilios and uncertain doctrines kindled into such a flame there, as subjected him to much scurrility and ill treatment, and endangered the very being of the academy. He died in 1761; and among several other judicious performances, his Hebrew and English Concordance, 2 vols folio, will remain a monument of his critical skill and indefatigable industry.

TAYLOR-BIRD. See MOTACILLA.

TEA, the dried leaves of the tea plant.—A commodity with which we are so well acquainted, which affords a beverage so generally used and so generally agreeable, and which forms so considerable an article of commerce, must excite the curiosity of the public at large to know something of its history, and of the nature of the

plant from which it is obtained. We are sorry that we can neither gratify their curiosity nor our own completely. We have consulted all the botanical books to which we had access, and we believe we have had access to the best, yet we have not been able to discover with certainty whether there be various species of the tea plant; or whether all the different kinds of tea, so unlike to one another in their flavour, and strength, and colour, be derived from one single species. As an apology for this imperfection in botanical knowledge, it is proper to observe, that the country of which the tea plant is a native is hidden from the exploring eye of the philosopher; that it is jealous of Europeans, and seldom gives them an opportunity of studying its productions. While we apologize for the ignorance of Europeans in this point, and sincerely regret it, we shall be careful to select every important fact, that we may present our readers with as accurate and complete an account as our materials can supply.

The tea plant is a native of Japan, China, and Tonquin, and has not, as far as we can learn, been found growing spontaneously in any other parts of the world. Linnæus arranged it under the class of *polyandria*, and order of *monogynia*. We are told he was led into this mistake from having no specimens of the flower to examine but such as were dried. If Linnæus has in this arrangement fallen into error, it is surprising that he has not been corrected by one who had the best opportunity of examining the matter. Sir Charles Thunberg, one of the most distinguished pupils of that illustrious botanist, who resided 16 months in Batavia and Japan, has given a full botanical description of the tea plant; and having classed it in the same manner as his master, says expressly that it has only one style. Several of the British botanists, on the other hand, refer it to the order of *trigynia*; deriving their authority from a plant in the Duke of Northumberland's garden at Sion-house, which had three styles.

Linnæus says that there are two species of the tea plant; the *bohea*, the corolla of which has six petals; and the *viridis* or green tea, which has nine petals. Thunberg makes only one species, the *bohea*, consisting of two varieties: the one with broad and the other with narrow leaves. This botanist's authority is decisive respecting the Japanese tea plants; but as China has not yet been explored, we cannot determine what number of species there are in that country. Of the *bohea* plant we have been favoured with a beautiful drawing, and an accurate botanical description, by a learned gentleman, which we shall here present to our readers.

Calyx. K, fig. 1, 2, 3, 10. a perianthium quinquepartite, very small, flat, the segments round, obtuse, permanent. Fig. 1. K.

Corolla. C, fig. 1, 3, 4, 5, 7, 8. the petals six, roundish, concave; two exterior (fig. 4, 7.) CC; less, unequal, inclosing the flower before fully blown (fig. 3.) C; four interior (fig. 5, 6.) CCCC; large, equal, before they fall off recurvate (fig. 8.) CC; (A).

Stamens. f, fig. 6, 9, 10, 11. the filaments numerous (B) fig. 6, 9 *fa*; about 200; filiform, white, shorter than the corolla, and inserted in the receptacle; *a*, the antheras cordate; and didymous (fig. 10, 11.) *, magnified (c).

Pistillum. Fig. 1, 10, 12. * magnified; *g*, the germen, three globular bodies joined in a triangular form; *s*, the styles, three, connected at their base (fig. 12.); subulate, re-

(A) Thunberg says, that three of the petals are exterior and three inferior.

(B) In a flower received from J. Ellis, Esq; upwards of 280 filaments were told.

(C) Kempfer describes the antheras as single.



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recurvate, of the length of the stamens, pressed together, and as if united in one by the thickset surrounding stamens (D) fig. 6, 9, 10.; but after the petals and stamens have fallen off they part, spread open, increase in length, and wither on the germen, fig. 1, 12.; the stigmas simple, *t*, fig. 1, 9, 10, 12.

Pericarpium. P, fig. 1, 13, 14. a capsule in the form of three globular bodies united, fig. 13. trilocular, fig. 14. gaping at the top in three directions, fig. 13.

Seeds. S, fig. 14. single, globose, angulate on the inward side.

Trunk. T, fig. 1. ramose, lignous, round; branches alternate, vague, stiffish, inclining to ash colour, towards the top reddish; the peduncles axillary, *p*, fig. 1. alternate, single, curved, uniflorous, incrassate, fig. 1, 2, 7. stipulate, the stipula single; subulate, erect, *d*, fig. 1, 2, 7, 9.

Leaves. E, fig. 1, 15, 16, 17. alternate, elliptical, obtusely serrated, with the edges between the teeth recurvate, with the apex emarginate (E) * magnified, fig. 15. *e*, at the base very entire, fig. 16, 17. the surface smooth, glossy, bullate, venose on the under side, of a firm texture, petiolate; the petioles very short, *b*, fig. 1, 16, 17. round on the under side, gibbous, fig. 16. *b*, * magnified; on the upper side flattish and slightly channelled, fig. 17. *b*.

The tea plant, which is an evergreen, grows to the height of five or six feet; Le Compte says ten or twelve. The leaves, which are the only valuable part of it, are about an inch and a half long, narrow, indented, and tapering to a point, like those of the sweet briar, and of a dark green colour. The root is like that of the peach tree, and its flowers resemble those of the white wild rose. The stem spreads into many irregular branches. The wood is hard, of a whitish green colour, and the bark is of a greenish colour, with a bitter, nauseous, and astringent taste. The fruit is small, and contains several round blackish seeds, about the bigness of a bean or large pea.

This plant delights in valleys, is frequent on the sloping sides of mountains and the banks of rivers, where it enjoys a southern exposure. It flourishes in the northern latitudes of Pekin as well as round Canton, but attains the greatest perfection in the mild temperate regions of Nankin. It is said only to be found between the 30th and 45th degree of north latitude. In Japan it is planted round the borders of fields, without regard to the soil; but as it is an important article of commerce with the Chinese, whole fields are covered with it, it is by them cultivated with care. The Abbé Rochen says, it grows equally well in a poor as in a rich soil; but that there are certain places where it is of a better quality. The tea which grows in rocky ground is superior to that which grows in a light soil; and the worst kind is that which is produced in a clay soil. It is propagated by seeds; from six to twelve are put into a hole about five inches deep, at certain distances from each other. The reason why so many seeds are sown in the same hole is said to be, that only a fifth part vegetate. Being thus sown, they grow without any other care. Some, however, manure the land, and remove the weeds; for the Chinese are as fond of good tea, and take as much pains to procure it of an excellent quality, as the Europeans do to procure excellent wine.

The leaves are not fit for being plucked till the shrub be

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of three years growth. In seven years it rises to a man's height; but as it then bears but few leaves, it is cut down to the stem, and this produces a new crop of fresh shoots the following summer, every one of which bears nearly as many leaves as a whole shrub. Sometimes the plants are not cut down till they are ten years old. We are informed by Kœmpfer, that there are three seasons in which the leaves are collected in the isles of Japan, from which the tea derives different degrees of perfection.

The first gathering commences at the end of February or beginning of March. The leaves are then small, tender, and unfolded, and not above three or four days old: these are called *ficki-tsiaa*, or "tea in powder," because it is pulverised; it is also called *imperial tea*, being generally reserved for the court and people of rank; and sometimes also it is named *bloom tea*. It is sold in China for 20 d. or 2 s. per pound. The labourers employed in collecting it do not pull the leaves by handfuls, but pick them one by one, and take every precaution that they may not break them. However long and tedious this labour may appear, they gather from 4 to 10 or 15 pounds a-day.

The second crop is gathered about the end of March or beginning of April. At this season part of their leaves have attained their full growth, and the rest are not above half their size. This difference does not, however, prevent them from being all gathered indiscriminately. They are afterwards picked and assorted into different parcels, according to their age and size. The youngest, which are carefully separated from the rest, are often sold for leaves of the first crop, or for imperial tea. Tea gathered at this season is called *too-tsiaa*, or "Chinese tea," because the people of Japan infuse it, and drink it after the Chinese manner.

The third crop is gathered in the end of May or in the month of June. The leaves are then very numerous and thick, and have acquired their full growth. This kind of tea, which is called *Ben-tsiaa*, is the coarsest of all, and is reserved for the common people. Some of the Japanese collect their tea only at two seasons of the year, which correspond to the second and third already mentioned; others confine themselves to one general gathering of their crop, towards the month of June: however, they always form afterwards different assortments of their leaves.

The finest and most celebrated tea of Japan is that which grows near Ud-si, a small village situated close to the sea, and not far distant from Meaco. In the district of this village is a delightful mountain, having the same name, the climate of which is said to be extremely favourable to the culture of tea; it is therefore inclosed by a hedge, and surrounded with wide ditches, which prevent all access to it. The tea shrubs that grow on this mountain are planted in regular order, and are divided by different avenues and alleys.

The care of this place is entrusted to people who are ordered to guard the leaves from dust, and to defend them from the inclemency of the weather. The labourers who are appointed to collect the tea abstain from every kind of gross food for some weeks before they begin, that their breath and perspiration may not in the least injure the leaves. They gather them with the most scrupulous nicety, and never touch them but with very fine gloves. When this choice tea has undergone the process necessary for its

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(D) It was this circumstance that led Linnæus to place it under the order monogynia.

(E) No author has hitherto remarked this obvious circumstance; even Kœmpfer says the leaves terminate in a sharp point.

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preparation, it is escorted by the superintendant of the mountain and a strong guard to the emperor's court, and reserved for the use of the imperial family.

As the tea shrub grows often on the rugged banks of steep mountains, access to which is dangerous, and sometimes impracticable, the Chinese, in order to come at the leaves, make use of a singular stratagem: These steep places are generally frequented by great numbers of monkeys, which being irritated and provoked, to revenge themselves tear off the branches, and shower them down upon those who have insulted them. The Chinese immediately collect these branches, and strip them of their leaves.

When the tea leaves have been collected, they are exposed to the steam of boiling water; after which they are put upon plates of copper, and held over the fire until they become dry and shrivelled, and appear such as we have them in Europe. According to the testimony of Kämpfer, tea is prepared in the same manner in the isles of Japan. "There are to be seen there (says this traveller) public buildings erected for the purpose of preparing the fresh gathered tea. Every private person who has not suitable conveniences, or who is unacquainted with the operation, may carry his leaves thither as they dry. These buildings contain a great number of small stoves raised about three feet high, each of which has a broad plate of iron fixed over its mouth. The workmen are seated round a large table covered with mats, and are employed in rolling the tea leaves which are spread out upon them. When the iron plates are heated to a certain degree by the fire, they cover them with a few pounds of fresh gathered leaves, which being green and full of sap crackle as soon as they touch the plate. It is then the business of the workman to stir them with his naked hands as quickly as possible, until they become so warm that he cannot easily endure the heat. He then takes off the leaves with a kind of shovel, and lays them upon mats. The people who are employed in mixing them, take a small quantity at a time, roll them in their hands always in the same direction; while others keep continually stirring them, in order that they may cool sooner, and preserve their shrivelled figure the longer. This process is repeated two or three times, and even oftener, before the tea is deposited in the warehouses. These precautions are necessary to extract all the moisture from the leaves."

The people of Japan and China generally keep their tea a year before using it, because, when quite fresh and newly gathered, it possesses a narcotic quality which hurts the brain. Imperial tea is generally preserved in porcelain vases, or in leaden or tin canisters covered with fine mats made of bamboo. Common tea is kept in narrow-mouthed earthen pots; and coarse tea, the flavour of which is not so easily injured, is packed up in baskets of straw.

An infusion of tea is the common drink of the Chinese; and indeed when we consider one circumstance in their situation, we must acknowledge that Providence has displayed much goodness in scattering this plant with so much profusion in the empire of China. The water is said to be unwholesome and nauseous, and would therefore perhaps, without some corrective, be unfit for the purposes of life. The Chinese pour boiling water over their tea, and leave it to infuse, as we do in Europe; but they drink it without any mixture, and even without sugar. The people of Japan reduce theirs to a fine powder, which they dilute with warm water until it has acquired the consistence of thin soup. Their manner of serving tea is as follows: They place before the company the tea equipage, and the box in which this powder is contained; they fill the cups with warm water, and taking from the box as much powder as the point of a knife can contain, throw it into each of the cups, and

stir it with a tooth-pick until the liquor begins to foam; it is then presented to the company, who sip it while it is warm. According to F. du Halde, this method is not peculiar to the Japanese; it is also used in some of the provinces of China.

The first European writer who mentions tea is Giovanni Botero, an eminent Italian author, who published a treatise about the year 1590, Of the Causes of the Magnificence and Greatness of Cities. He does not indeed mention its name, but describes it in such a manner that it is impossible to mistake it. "The Chinese (says he) have an herb out of which they press a delicate juice, which serves them for drink instead of wine: it also preserves their health, and frees them from all those evils which the immoderate use of wine produces among us *."

Tea was introduced into Europe in the year 1610 by the Dutch East India Company. It is generally said, that it was first imported from Holland into England, in 1656, by the lords Arlington and Ossory, who brought it into fashion among people of quality. But it was used in coffee-houses before this period, as appears from an act of parliament made in 1660, in which a duty of 8 d. was laid on every gallon of the infusion sold in these places. In 1666 it was sold in London for 60 s. per pound, though it did not cost more than 2 s. 6 d. or 3 s. 6 d. at Batavia. It continued at this price till 1707. In 1715 green tea began to be used; and as great quantities were then imported, the price was lessened, and the practice of drinking tea descended to the lower ranks †. In 1720 the French began to send it to us by a clandestine commerce. Since that period the demand has been increasing yearly, and it has become almost a necessary of life in several parts of Europe, and among the lowest as well as the highest ranks.

The following table will give an idea of the quantity of tea imported annually into Great Britain and Ireland since 1717:

From 1717 to 1726	-	700,000 lbs.
1732 to 1742	-	1,200,000
1755 near	-	4,000,000
1766	-	6,000,000
1785 about	-	12,000,000
1794 from	16 to 20,000,000	

Besides these immense quantities imported into Britain and Ireland, much has been brought to Europe by other nations. In 1766 the whole tea imported into Europe from China amounted to 17 millions of pounds; in 1785 it was computed to be about 19 millions of pounds ‡.

Several researches have been made in Europe to determine whether the tea plant grows spontaneously; but these researches have been hitherto in vain. When Captain Cook visited Teneriffe in his last voyage, Mr Anderson his surgeon was informed by a gentleman of acknowledged veracity, that a shrub is common near Santa Cruz which agrees exactly with the description given of the tea-plant by Linnaeus. It is considered as a weed, and large quantities are rooted out of the vineyards every year: But the Spaniards who inhabit the island sometimes make use of it, and ascribe to it all the qualities of the tea imported from China.

Many attempts have been made to introduce this valuable plant into Europe; but from want of proper precautions most of these attempts have miscarried. The seeds, being of an oily nature, are apt to grow rancid during a long voyage, unless proper care is taken to preserve them. There are two methods of preserving these seeds: The first is, to inclose them in wax after they have been dried in the sun; the second is, to leave them in their husks, and shut them up closely in a box made of tin: but neither of these methods has been attended with general success, whatever care

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* Anderson's
Commerce,
vol. ii.
p. 138.

† Harewood's
Journal.

‡ Raynal,
vol. i. and
Robertson's
India.

Tea. care has been taken to obtain fresh seeds, or to preserve them. The best method would be, to sow fresh seeds in fine light earth immediately on leaving Canton, and to cover them with wire to secure them from rats and other animals that might attack them. The boxes ought not to be too much exposed to the air, nor to that kind of dew which rises from the sea. The earth in the boxes must neither be hard nor dry, and should from time to time be gently watered with fresh or rain water; and when the shoots begin to appear, they ought to be kept in a slight moisture, and sheltered from the sun. The tea-plants to be found in England have been procured by these means only; and though several of the young rising shoots perished, the last method proposed is probably that which may be followed with greatest success.

The finest tea-plant known in England was raised in Kew gardens; it was carried thither by Sir J. Ellis, who brought it from seed: but the first that ever flourished in Europe was one belonging to the Duke of Northumberland at Sion, from a drawing of which our engraving is taken. The plants which are cultivated in the gardens near London thrive well in the green-house during winter, and some stand that season in the open air. Linnæus, who obtained this shrub in its growing state, contrived to preserve it in the open air in the northern latitude of Sweden. France has also procured some plants. There can be no doubt but they would succeed in many countries of Europe, if proper care were paid to their cultivation till they became inured to one climate. It will be a great advantage if we can rear that plant, which can never suffer so much from change of soil as from growing musty during the long voyage from China. Besides, the demand for tea is now become so great, that the Chinese find it necessary, or at least profitable, to adulterate it. Bad tea is now become an universal complaint. The Abbé Grosier tells us, that there is a kind of moss which grows in the neighbourhood of the little city of Mang-ing-hien, which is sold as a delicate species of tea. If this delicious commodity is adulterated in China, can we flatter ourselves that none comes to us but what is pure and unmixed? How would our fine ladies like to be told, that instead of tea they drink nothing but the infusion of moss from the rocks of Mang-ing-hien (F)?

Of the chemical qualities and effects of tea on the constitution, many various and opposite opinions have been formed. About a century ago, Bontikoe, a Dutch physician, bestowed extravagant encomiums on the benefits of tea. With him it was good for every thing; and any quantity might be drunk, even to the amount of 200 dishes in a

day. Whether Bontikoe in this case acted as a physician, or, being a Dutchman, was eager to encourage the sale of an important article of his country's commerce, is not easy to say. On the other hand, the pernicious effects of tea upon the nervous system have been often repeated, and very opposite effects have been ascribed to it. Some affirm that green tea is mildly astringent; others say it is relaxing: Some say it is narcotic, and procures sleep; while others contend, that taken before bed-time it assuredly prevents it.

Dr Lettsom, who has written the Natural History of the Tea Tree, made several experiments to determine its chemical qualities. He found an infusion of it preserved beef fresh; it is therefore antiseptic: and from its striking a purple colour with the salt (sulphate) of iron, he justly concludes that it is astringent. He concludes also, that the essential qualities of tea reside in its fragrant and volatile parts.

We have heard much of the bad effects of tea, but we have neither felt nor observed it. If it were so pernicious as it has been represented by some, its effects must certainly be evident in China, where it is drunk by all ranks; yet so far from being thought hurtful in that country, it is in high estimation. The present emperor has composed a kind of eulogy on the virtues of tea. We are told by those who have written the history of China, that inflammatory diseases are less frequent there than in many other countries, which is ascribed solely to the liberal use of tea. It must be observed by all, that tea is an antidote against intemperance, and that he who relishes the one seldom runs into the other. Raynal says, that tea has contributed more to the sobriety of this nation than the severest laws, the most eloquent harangues of Christian orators, or the best treatises of morality. We have no doubt but it may be hurtful to some constitutions in particular circumstances; but we suspect that the nervous disorders so often attributed to tea, are rather owing to hereditary diseases, to want of exercise, and to irregularity in food or sleep, than to tea. "Weak tea drunk too hot (says Dr Leake) will enervate, and if very strong, may prove equally pernicious by affecting the head or stomach. But when it is drunk in moderation, and not too warm, with a large addition of milk, I believe it will seldom prove hurtful, but, on the contrary, salutary. After study or fatigue it is a most refreshing and grateful repast; it quenches thirst, and cheers the spirits, without heating the blood; and the pleasing society, in which we so often partake of it, is no inconsiderable

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(F) There is very good reason to believe, that the adulteration of tea is not confined to China. It is practised, and often with too much success, among ourselves. Mr Twining, a considerable tea-dealer in London, published a pamphlet some years ago, in which he has exposed this infamous traffic. The information (he says) was obtained from a gentleman who had made very accurate inquiries into this subject.

The smouch for mixing with black teas is made of the leaves of the ash. When gathered, they are first dried in the sun, then baked: they are next put upon a floor, and trod upon until the leaves are small, then sifted and steeped in copperas with sheeps dung; after which, being dried on a floor, they are fit for use. There is also another mode: When the leaves are gathered, they are boiled in a copper with copperas and sheeps dung; when the liquor is strained off, they are baked and trod upon, until the leaves are small, after which they are fit for use. The quantity manufactured at a small village, and within eight or ten miles thereof, cannot be ascertained, but is supposed to be about 20 tons in a year. One man acknowledges to have made 600 weight in every week for six months together. The fine is sold at 4l. 4s. per cwt. equal to 9d. per lb. The coarse is sold at 2l. 2s. per cwt. equal to 4½d. per lb. Elder buds are manufactured in some places to represent fine teas.

For the honour of human nature, we hope such a traffic as this is not very common; but if there be, those concerned in it deserve exemplary punishment. The only way (Mr Twining says) to escape this adulterated tea, is never to purchase from those who offer their teas to sale at lower prices than genuine teas can be afforded; but to purchase them only from persons of character.

Tea,
Teachers.

addition to its value; for whatever affords rational pleasure to the mind, will always contribute to bodily health.

In this country teas are generally divided into three kinds of green, and five of bohea: The former are, 1. Imperial or bloom tea, with a large loose leaf, light green colour, and a faint delicate smell. 2. Hyson, so called from the name of the merchant who first imported it; the leaves of which are closely curled and small, of a green colour, verging to a blue: And, 3. Singlo tea, from the name of the place where it is cultivated. The boheas are, 1. Sou-chong, which imparts a yellow green colour by infusion. 2. Camho, so called from the place where it is made; a fragrant tea, with a violet smell; its infusion pale. 3. Congo, which has a larger leaf than the following, and its infusion somewhat deeper, resembling common bohea in the colour of the leaf. 4. Pekoe tea; this is known by the appearance of small white flowers mixed with it. 5. Common bohea, whose leaves are of one colour. There are other varieties, particularly a kind of green tea, done up in roundish balls, called *gunpowder tea*.

Tea-Tree of New Zealand, is a species of myrtle, of which an infusion was drunk by Captain Cook's people in their voyages round the world. Its leaves were finely aromatic, astringent, and had a particular pleasant flavour at the first infusion; but this went off at the next filling up of the tea-pot, and a great degree of bitterness was then extracted; for which reason it was never suffered to be twice infused. In a fine soil in thick forests this tree grows to a considerable size; sometimes 30 or 40 feet in height, and one foot in diameter. On a hilly and dry exposure it degenerates into a shrub of five or six inches; but its usual size is about eight or ten feet high, and three inches in diameter. In that case its stem is irregular and unequal, dividing very soon into branches, which rise at acute angles, and only bear leaves and flowers at top. The flowers are white, and very ornamental to the whole plant.

Mr White, in his *Journal of a Voyage to New South Wales*, mentions a shrub which he calls a *tea-tree*, merely from its being used by the convicts as a succedaneum for tea; for he had not seen the flower, nor did he know to what genus it belonged. It is a creeping kind of a vine, running to a great extent along the ground; the stalk slender; the leaf not so large as the common bay leaf; the taste sweet, exactly like the liquorice root of the shops.

TEACHERS, persons employed in conducting the education of the young.

We will venture to say, that there is no class of men to whom a nation is so much indebted as to those employed in instructing the young: For if it be education that forms the only distinction between the civilized and the savage, much certainly is due to those who devote themselves to the office of instruction. It must be the duty therefore of every state to take care that proper encouragement be given to those who undertake this office. There ought to be such a salary as would render it an object of ambition to men of abilities and learning, or at least as would keep the teacher respectable. In Scotland, the office of a schoolmaster was formerly much more lucrative than at present, and most of that class had received liberal education; and this is the reason why the common people in Scotland have been famous, even to a proverb, for their learning. But at present the salary of a country schoolmaster, independent of fees for scholars, is not greater than a ploughman can earn, being seldom more than L. 8 : 6 : 8, the consequence of which is, that this, which is in fact an honourable, because an useful profession, is now sinking into contempt. It is no longer an

object to a man of learning; and we must soon be satisfied with schoolmasters that can read, write, and cast accounts, a little better than the lowest of the people, or who from some natural deformity are unable to exercise a trade. And what in this case must become of the minds of the common people? They must be totally uncultivated.

We have observed a great difference between the cultivation of the common people in one part of Scotland compared with another; and we have found, that wherever a schoolmaster is looked upon as a mean profession, there is scarcely a duly qualified person to be found to undertake the office; and in those places the common people are lamentably ignorant. In other places a man, where the schoolmaster is considered as one of the principal persons in the parish, there men of a liberal education, young divines, and preachers, do not think themselves disgraced by exercising this profession; and there the common people show a degree of acuteness, knowledge, and observation, and possess such polished manners, as raise them very high above those of their own rank in other parts of the country.

Many and keen have been the debates about a reform of government of late years; but little attention has been paid to the formation of the minds of the common people, who constitute the greater part of the nation; of course they are ready to join the standard of every seditious demagogue who sounds the alarm of oppression; and should they at length be roused, their cruelty and barbarity, like the common people of France, would be exactly in proportion to their ignorance and want of principle.

We are willing to hope, then, that the government and the monied men of the nation, who alone have property to lose and money to bestow, will at length find it to be their interest to patronize schoolmasters.

TEAL, in ornithology. See ANAS.

TEARS, a lymph or aqueous humour, which is limpid, and a little saltish: it is separated from the arterial blood by the lachrymal glands and small glandulous grains on the inside of the eyelids.

TEASELS, a plant cultivated in the west of England for the use of clothiers. See DIPSACUS.

TEBETH, the tenth month of the Jewish ecclesiastical year, and fourth of the civil. It answers to our month of December.

TECKLENBURG, a town of Germany, in the circle of Westphalia, capital of a county of the same name, with a castle built on a hill. It was bought by the king of Prussia in 1707. E. Long. 8. 2. N. Lat. 52. 20.

TECHNICAL, expresses somewhat relating to arts or sciences: in this sense we say technical terms. It is also particularly applied to a kind of verses wherein are contained the rules or precepts of any art, thus digested to help the memory to retain them; an example whereof may be seen in the article MEMORY.

TECTONA, in botany; a genus of plants belonging to the class of *pentandria*, and order of *monogynia*. The stigma is dentate; the fruit a dry spongy plum within an inflated calyx; and the nucleus is trilocular. There is only one species, the *grandis*, Indian oak, or teak wood, which is a native of India.

TE DEUM, the name of a celebrated hymn, used in the Christian church, and so called because it begins with these words, *Te Deum laudamus*, We praise thee, O God. It is sung in the Romish church with great pomp and solemnity upon the gaining of a victory, or other happy event; and is believed to be the composition of ST AMBROSE bishop of Milan.

TEES, a river which rises on the confines of Cumberland,

Teachers
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Tees.

Teeth
||
Teff.

land, and running eastward, divides the county of Durham from Yorkshire, and falls into the German sea below Stockton.

TEETH, the bones placed in the jaws for chewing food, that it may be the more easily digested in the stomach. The anatomical structure of these has already been described under **ANATOMY** and **COMPARATIVE ANATOMY**. The diseases to which they are liable, as well as the most successful remedies for removing them, are fully detailed under **MEDICINE** and **SURGERY**, to which we refer the reader.

Much attention has been paid to the beauty and preservation of the teeth among most nations. The Romans rubbed and washed them with great care; and when they lost them, supplied their place with artificial teeth made of ivory; and sometimes, when loose, bound them with gold. Ligatures of wire have been found to hurt the natural teeth with which the artificial are connected: whereas silken twist cannot affect them to any considerable degree for several years.

Guilleman gives us the composition of a paste for making artificial teeth, which shall never grow yellow: the composition is white wax granulated, and melted with a little gum elemi, adding powder of white mastich, coral, and pearl.

When several teeth are out in the same place, it is best to make a set, or the number wanted, out of one piece, all adhering together, which may be fastened to the two next of the sound or natural teeth. And even a whole set of artificial teeth may be made for one or both jaws, so well fitted to admit of the necessary motions, and so conveniently retained in the proper situation by means of springs, that they will answer every purpose of natural teeth, and may be taken out, cleaned, and replaced, by the patient himself with great ease.

The common trick of mountebanks and other such practitioners, is to use various washes for teeth, the sudden effects of which, in cleaning and whitening the teeth, surprise and please people; but the effects are very pernicious. All the strong acid spirits will do this. As good a mixture as any thing can be, on this occasion, is the following: take plantane-water an ounce, honey of roses two drams, muriatic acid ten drops; mix the whole together, and rub the teeth with a piece of linen rag dipped in this every day till they are whitened. The mouth ought to be well washed with cold water after the use of this or any other acid liquor; and indeed the best of all teeth washes is cold water, with or without a little salt; the constant use of this will keep them clean and white, and prevent them from aching.

After all the numerous cures which have been proposed for preventing the toothach, we will venture to recommend the keeping the teeth clean as the most efficacious, and avoiding every kind of hot food, especially hot liquids, as tea, &c. They who are constantly using powders generally destroy their teeth altogether, as the valetudinarian does his health.

TEETHING in children. See **MEDICINE**.

TEFF, a kind of grain, sown all over Abyssinia, from which is made the bread commonly used throughout the country. We have no description of this plant but from Mr Bruce, who says that it is herbaceous; and that from a number of weak leaves surrounding the root proceeds a stalk of about 28 inches in length, not perfectly straight, smooth, but jointed or knotted at particular distances. This stalk is not much thicker than that of a carnation or jellyflower. About eight inches from the top, a head is formed of a number of small branches, upon which it carries the fruit and flowers; the latter of which is small, of a crimson colour, and scarcely perceptible by the naked eye but from

the opposition of that colour. The pistil is divided into two, seemingly attached to the germ of the fruit, and has at each end small capillaments forming a brush. The stamina are three in number; two on the lower side of the pistil, and one on the upper. These are each of them crowned with two oval stigmata, at first green, but after crimson. The fruit is formed in a capsula, consisting of two conical hollow leaves, which, when closed, seems to compose a small conical pod, pointed at the top. The fruit or seed is oblong, and is not so large as the head of the smallest pin; yet it is very prolific, and produces these seeds in such quantity as to yield a very abundant crop in the quantity of meal.

Our author, from the similarity of the names, conjectures it to be the *tipha* mentioned, but not described, by Pliny: but this conjecture, which he acknowledges to be unsupported, is of very little importance.

There are three kinds of meal made from teff, of which the best (he says) is as white as flour, exceedingly light, and easily digested; the second is of a browner colour; and the last, which is the food of soldiers and servants, is nearly black. This variety he imagines to arise entirely from the difference of soils in which the seeds are sown, and the different degrees of moisture to which the plant is exposed when growing. The manner of making the meal or flour into bread is by taking a broad earthen jar, and having made a lump of it with water, they put it into an earthen jar at some distance from the fire, where it remains till it begins to ferment or turn sour; they then bake it into cakes of a circular form, and about two feet in diameter: it is of a spongy soft quality, and not a disagreeable sourish taste. Two of these cakes a-day, and a coarse cotton cloth once a-year, are the wages of a common servant.

At their banquets of raw meat, the flesh being cut in small bits, is wrapt up in pieces of this bread, with a proportion of fossil salt and Cayenne pepper. Before the company sits down to eat, a number of these cakes of different qualities are placed one upon the other, in the same manner as our plates, and the principal people sitting first down, eat the white teff; the second or coarser sort serves the second rate people that succeed them, and the third is for the servants. Every man, when he is done, dries or wipes his fingers upon the bread which he is to leave for his successor, for they have no towels; and this is one of the most beastly customs among them.

Of this teff bread the natives make a liquor, by a process which our author describes in the following words: The bread, when well toasted, is broken into small pieces, which are put into a large jar, and have warm water poured upon them. It is then set by the fire, and frequently stirred for several days, the mouth of the jar being close covered. After being allowed to settle three or four days, it acquires a sourish taste, and is what they call *bouza*, or the common beer of the country. The *bouza* in Atbara is made in the same manner, only instead of teff, cakes of barley-meal are employed. Both are very bad liquors, but the worst is that made of barley.

TEFFLIS, or **TIFFLIS**, a town of Asia, in Georgia, one of the seven nations between the Black Sea and the Caspian. It is the capital of that country, the place of residence of its sovereign, and is called by the inhabitants *Thilicabar*, "warm town," from the warm baths in its neighbourhood. Though its circumference does not exceed two English miles, it contains 20,000 inhabitants, of which more than half are Armenians; the remainder are principally Georgians, with some Tartars. According to Major Rennel, it has 20 Armenian and 15 Greek churches, and three metsheds. But Mr Coxe, on the authority of Professor

Teff,
Tefflis.

Tesslis
Telegraph.

Guldenstaedt, states the places of worship to be one Roman Catholic, 13 Greek, and seven Armenian churches. There are some magnificent caravanseras, bazars, and palaces in the city, but no mosques; for the Georgians, though living under a Mohammedan government, have always risen up in arms as often as any attempts have been made to erect such places of Mohammedan worship. Many of the Romish missionaries live here in disguise under the denomination of physicians, surgeons, and chemists; and the great cures which they perform procure them much esteem, though they are sometimes exposed to the insults of the people when they attempt to make any proselytes to their church. All the houses are of stone, with flat roofs, which serve, according to the custom of the East, as walks for the women. They are neatly built; the rooms are wainscotted, and the floors spread with carpets. The streets seldom exceed seven feet in breadth; and some are so narrow as scarcely to allow room for a man on horseback: they are consequently very filthy.

Tesslis is a place of considerable trade, especially in furs, which are conveyed hence to Constantinople by the way of Erzerum. As for the silks of this country, they are bought up on the spot by the Armenians, and conveyed to Smyrna and other ports of the Mediterranean; but the greatest part is first sent to Erzerum to be manufactured, the Georgians being very ignorant and unskilful in that respect. From hence, likewise, great quantities of a root called *boya* is sent to Erzerum and Indostan for the use of the linen dyers. Here is likewise a foundery, at which are cast a few cannon, mortars, and balls, all of which are very inferior to those of the Turks. The gunpowder made here is very good. The Armenians have likewise established in this town all the manufactures carried on by their countrymen in Persia: the most flourishing is that of printed linens. Tesslis is seated on the river Kur, at the foot of a mountain; and on the south side of it stands a large castle or fortress, built by the Turks in 1576, when they made themselves masters of the city and country, under the command of the famous Mustapha Pacha. It is 125 miles west of Terki. E. Long. 63. 3. N. Lat. 41. 59.

TEGERHY, a principal town in Fezzan, in Africa, about 80 miles south-west of the capital. It collects from its lands little other produce than dates and Indian corn. In this, as in every town in Fezzan, a market for butcher-meat, corn, fruit, and vegetables, is regularly held. Mutton and goats flesh are sold by the quarter without weighing; the usual price is from 32 to 40 grains of gold-dust, or four or five shillings English money. The flesh of the camel, which is much more highly valued, is commonly sold at a dearer rate, and is divided into smaller lots. Agriculture and pasturage seem to be the principal occupations.

TEGUMENT, any thing that surrounds or covers another.

TEIND in Scots law. See LAW, N° clxx.

Commission of TEINDS. See COMMISSION.

TEINTS, and SEMITEINTS, in painting, denote the several colours used in a picture, considered as more or less high, bright, deep, thin, or weakened and diminished, &c. to give the proper relievo, softness, or distance, &c. of the several objects.

TELEGRAPH (derived from *τῆλε* and *γραφω*), is the name very properly given to an instrument, by means of which information may be almost instantaneously conveyed to a considerable distance.

The telegraph, though it has been generally known and used by the moderns only for a few years, is by no means a modern invention. There is reason to believe that amongst

the Greeks there was some sort of telegraph in use. The burning of Troy was certainly known in Greece very soon after it happened, and before any person had returned from thence. Now that was altogether so tedious a piece of business, that conjecture never could have supplied the place of information. A Greek play begins with a scene, in which a watchman descends from the top of a tower in Greece, and gives the information that Troy was taken. "I have been looking out these ten years (says he) to see when that would happen, and this night it is done." Of the antiquity of a mode of conveying intelligence quickly to a great distance, this is certainly a proof.

The Chinese, when they send couriers on the great canal, or when any great man travels there, make signals by fire from one day's journey to another, to have every thing prepared; and most of the barbarous nations used formerly to give the alarm of war by fires lighted on the hills or rising grounds.

Polybius calls the different instruments used by the ancients for communicating information *πυρρα*, because the signals were always made by means of fire. At first they communicated information of events merely by torches; but this method was of little use, because it was necessary before-hand to fix the meaning of every particular signal. Now as events are exceedingly various, it was impossible to express the greater number of them by any premeditated contrivance. It was easy, for instance, to express by signals that a fleet had arrived at such a place, because this had been foreseen, and signals accordingly had been agreed upon to denote it; but an unexpected revolt, a murder, and such accidents, as happen but too often, and require an immediate remedy, could not be communicated by such signals; because to foresee them was impossible.

Æneas, a contemporary of Aristotle, who wrote a treatise on the duties of a general, endeavoured to correct those imperfections, but by no means succeeded. "Those (says he) who would give signals to one another upon affairs of importance, must first prepare two vessels of earth, exactly equal in breadth and depth; and they need be but four feet and a half deep, and a foot and a half wide. They then must take pieces of cork, proportioned to the mouth of these vessels, but not quite so wide, that they may be let down with ease to the bottom of these vessels. They next fix in the middle of this cork a stick, which must be of equal size in both these vessels. This stick must be divided exactly and distinctly, by spaces of three inches each, in order that such events as generally happen in war may be writ on them. For example, on one of these spaces the following words may be writ: 'A BODY OF HORSE ARE MARCHED INTO THE COUNTRY.' On another, 'A BODY OF INFANTRY, heavily armed, are arrived hither.' On a third, 'INFANTRY LIGHTLY ARMED.' On a fourth, 'HORSE AND FOOT.' On another, 'SHIPS,' then 'PROVISIONS;' and so on till all the events which may probably happen in the war that is carrying on are writ down in these intervals.

This being done, each of the two vessels must have a little tube or cock of equal bigness, to let out the water in equal proportion. Then the two vessels must be filled with water; the pieces of cork, with their sticks thrust through them, must be laid upon them, and the cocks must be opened. Now, it is plain, that as these vessels are equal, the corks will sink, and the sticks descend lower in the vessels, in proportion as they empty themselves. But to be more certain of this exactness, it will be proper to make the experiment first, and to examine whether all things correspond and agree together, by an uniform execution on both sides. When they are well assured of this, the two vessels must be carried to the two places where the signals are to be made and

Telegraph and observed: water is poured in, and the corks and sticks are put in the vessels. When any of the events which are written on the sticks shall happen, a torch or other light is raised, which must be held aloft till such time as another is raised by the party to whom it is directed. (This first signal is only to give notice that both parties are ready and attentive). Then the torch or other light must be taken away, and the cocks set open. When the interval, that is, that part of the stick where the event of which notice is to be given or written, shall be fallen to a level with the vessels, then the man who gives the signal lifts up his torch; and on the other side, the correspondent signal-maker immediately turns the cock of his vessel, and looks at what is writ on that part of the stick which touches the mouth of the vessel: on which occasion, if every thing has been executed exactly and equally on both sides, both will read the same thing."

This method was defective, because it could not convey any other intelligence except what was written on the sticks, and even that not particularly enough. With regard to all unforeseen events, it was quite useless.

Polybius,
ibid.

A new method was invented by Cleoxenus (others say by Democlitus), and very much improved by Polybius, as he himself informs us. He describes this method as follows: Take the letters of the (Greek) alphabet, and divide them into five parts, each of which will consist of five letters, except the last division, which will have only four. Let these be fixed on a board in five columns. The man who is to give the signals is then to begin by holding up two torches, which he is to keep aloft till the other party has also shown two. This is only to show that both sides are ready. These first torches are then withdrawn. Both parties are provided with boards, on which the letters are disposed as formerly described. The person then who gives the signal is to hold up torches on the left to point out to the other party from what column he shall take the letters as they are pointed out to him. If it is to be from the first column, he holds up one torch; if from the second, two; and so on for the others. He is then to hold up torches on the right, to denote the particular letter of the column that is to be taken. All this must have been agreed on before-hand. The man who gives the signals must have an instrument (*διπλῆραν*), consisting of two tubes, and so placed as that, by looking through one of them, he can see only the right side, and through the other only the left, of him who is to answer. The board must be set up near this instrument; and the station on the right and left must be surrounded with a wall (*παράπετρα*) ten feet broad, and about the height of a man, that the torches raised above it may give a clear and strong light, and that when taken down they may be completely concealed. Let us now suppose that this information is to be communicated—*A number of the auxiliaries, about a hundred, have gone over to the enemy.* In the first place, words must be chosen that will convey the information in the fewest letters possible; as, *A hundred Cretans have deserted*, *Κεντρὶς εκατὸν ἀπ' ἡμῶν πύλομολησαν*. Having written down this sentence, it is conveyed in this manner. The first letter is a κ, which is in the second column; two torches are therefore to be raised on the left hand to inform the person who receives the signals to look into that particular column. Then five torches are to be held up on the right, to mark the letter *k*, which is the last in the column. Then four torches are to be held up on the left to point out the *ε* (*r*), which is in the fourth column, and two on the right to show that it is the second letter of that column. The other letters are pointed out in the same manner.—Such was the *pyrsia* or telegraph recommended by Polybius.

But neither this nor any other method mentioned by the ancients seems ever to have been brought into general use;

nor does it appear that the moderns had thought of such a machine as a *telegraph* till the year 1663, when the Marquis of Worcester, in his *CENTURY OF INVENTIONS*, affirmed that he had discovered "a method by which, at a window, as far as eye can discover black from white, a man may hold discourse with his correspondent, without noise made or notice taken; being according to occasion given, or means afforded, *ex re nata*, and no need of provision before hand; though much better if foreseen, and course taken by mutual consent of parties." This could be done only by means of a telegraph, which in the next sentence is declared to have been rendered so perfect, that by means of it the correspondence could be carried on "by night as well as by day, though as dark as pitch is black."

About 40 years afterwards M. Amontons proposed a new telegraph. His method was this: Let there be people placed in several stations, at such a distance from one another, that by the help of a telescope a man in one station may see a signal made in the next before him; he must immediately make the same signal, that it may be seen by persons in the station next after him, who are to communicate it to those in the following station, and so on. These signals may be as letters of the alphabet, or as a cipher, understood only by the two persons who are in the distant places, and not by those who make the signals. The person in the second station making the signal to the person in the third the very moment he sees it in the first, the news may be carried to the greatest distance in as little time as is necessary to make the signals in the first station. The distance of the several stations, which must be as few as possible, is measured by the reach of a telescope. Amontons tried this method in a small tract of land before several persons of the highest rank at the court of France.

It was not, however, till the French revolution that the telegraph was applied to useful purposes. Whether M. Chappe, who is said to have invented the telegraph first used by the French about the end of 1793, knew any thing of Amontons's invention or not, it is impossible to say; but his telegraph was constructed on principles nearly similar. The manner of using this telegraph was as follows: At the first station, which was on the roof of the palace of the Louvre at Paris, M. Chappe, the inventor, received in writing, from the committee of public welfare, the words to be sent to Lille, near which the French army at that time was. An upright post was erected on the Louvre, at the top of which were two transverse arms, moveable in all directions by a single piece of mechanism, and with inconceivable rapidity. He invented a number of positions for these arms, which stood as signs for the letters of the alphabet; and these, for the greater celerity and simplicity, he reduced in number as much as possible. The grammarian will easily conceive that sixteen signs may amply supply all the letters of the alphabet, since some letters may be omitted not only without detriment but with advantage. These signs, as they were arbitrary, could be changed every week; so that the sign of B for one day might be the sign of M the next; and it was only necessary that the persons at the extremities should know the key. The intermediate operators were only instructed generally in these sixteen signals; which were so distinct, so marked, so different the one from the other, that they were easily remembered. The construction of the machine was such, that each signal was uniformly given in precisely the same manner at all times: It did not depend on the operator's manual skill; and the position of the arm could never, for any one signal, be a degree higher or a degree lower, its movement being regulated mechanically.

M. Chappe having received at the Louvre the sentence:

Telegraph. to be conveyed, gave a known signal to the second station, which was Mont Martre, to prepare. At each station there was a watch tower, where telescopes were fixed, and the person on watch gave the signal of preparation which he had received, and this communicated successively through all the line, which brought them all into a state of readiness. The person at Mont Martre then received, letter by letter, the sentence from the Louvre, which he repeated with his own machine; and this was again repeated from the next height, with inconceivable rapidity, to the final station at Lille.

*English
Review,
June 1796.*

The first description of the telegraph was brought from Paris to Frankfort on the Maine by a former member of the parliament of Bourdeaux, who had seen that which was erected on the mountain of Belville. As given by Dr Hutton from some of the English papers, it is as follows. AA is a beam or mast of wood placed upright on a rising ground (fig. 1. Plate DII.), which is about 15 or 16 feet high. BB is a beam or balance moving upon the centre AA. This balance-beam may be placed vertically or horizontally, or any how inclined, by means of strong cords, which are fixed to the wheel D, on the edge of which is a double groove to receive the two cords. This balance is about 11 or 12 feet long, and nine inches broad, having at the ends two pieces of wood CC, which likewise turn upon angles by means of four other cords that pass through the axis of the main balance, otherwise the balance would derange the cords; the pieces C are each about three feet long, and may be placed either to the right or left, straight or square, with the balance-beam. By means of these three the combination of movement is very extensive, remarkably simple, and easy to perform. Below is a small wooden gouge or hut, in which a person is employed to observe the movements of the machine. In the mountain nearest to this another person is to repeat these movements, and a third to write them down. The time taken up for each movement is 20 seconds; of which the motion alone is four seconds, the other 16 the machine is stationary. Two working models of this instrument were executed at Frankfort, and sent by Mr W. Playfair to the Duke of York; and hence the plan and alphabet of the machine came to England.

Various experiments were in consequence tried upon telegraphs in this country; and one was soon after set up by government in a chain of stations from the admiralty-office to the sea coast. It consists of six octagon boards, each of which is poised upon an axis in a frame, in such a manner that it can be either placed vertically, so as to appear with its full size to the observer at the nearest station, as in fig. 2. or it becomes invisible to him by being placed horizontally, as in fig. 3. so that the narrow edge alone is exposed, which narrow edge is from a distance invisible. Fig. 2. is a representation of this telegraph, with the parts all shut, and the machine ready to work. T, in the officer's cabin, is the telescope pointed to the next station. Fig. 3. is a representation of the machine not at work, and with the ports all open. The opening of the first port (fig. 2.) expresses *a*, the second *b*, the third *c*, the fourth *d*, the fifth *e*, and the sixth *f*, &c.

Six boards make 36 changes, by the most plain and simple mode of working; and they will make many more if more were necessary: but as the real superiority of the telegraph over all other modes of making signals consists in its making letters, we do not think that more changes than the letters of the alphabet, and the ten arithmetical ciphers, are necessary; but, on the contrary, that those who work the telegraphs should avoid communicating by words or signs agreed upon to express sentences; for that is the sure method never to become expert at sending unexpected intelligence accurately.

This telegraph is without doubt made up of the best number of combinations possible; five boards would be insufficient, and seven would be useless. It has been objected to it, however, that its form is too clumsy to admit of its being raised to any considerable height above the building on which it stands; and that it cannot be made to change its direction, and consequently cannot be seen but from one particular point.

Several other telegraphs have been proposed to remedy these defects, and perhaps others to which the instrument is still liable. The dial-plate of a clock would make an excellent telegraph, as it might exhibit 144 signs so as to be visible at a great distance. A telegraph on this principle, with only six divisions instead of twelve, would be simple and cheap, and might be raised 20 or 30 feet high above the building without any difficulty: it might be supported on one post, and therefore turn round, and the contrast of colours would always be the same.

A very ingenious improvement of the telegraph has been proposed in the Gentleman's Magazine. It consists of a semicircle, to be properly elevated, and fixed perpendicularly on a strong stand. The radius 12 feet; the semicircle consequently somewhat more than 36. This to be divided into 24 parts. Each of these will therefore comprise a space of 18 inches, and an arch of $7^{\circ} 30'$ on the circumference. These 24 divisions to be occupied by as many circular apertures of six inches diameter; which will leave a clear space of six inches on each side between the apertures. These apertures, beginning from the left, to denote the letters of the alphabet, omitting K, J consonant, V, X, and Q, as useless for this purpose. There are then 21 letters. The four other spaces are reserved for signals. The instrument to have an index moveable by a windlass on the centre of the semicircle, and having two tops, according as it is to be used in the day or night; one, a circular top of lacquered iron or copper, of equal diameter with the apertures (and which consequently will eclipse any of them against which it rests); the other, a spear or arrow-shaped top, black, and highly polished, which, in standing before any of the apertures in the day-time, will be distinctly visible. In the night, the apertures to be reduced by a diaphragm sitting close to each, so as to leave an aperture of not more than two inches diameter. The diaphragm to be of well-polished tin; the inner rim lacquered black half an inch. All the apertures to be illuminated, when the instrument is used in the night-time, by small lamps; to which, if necessary, according to circumstances, convex lenses may be added, fitted into each diaphragm, by which the light may be powerfully concentrated and increased. Over each aperture one of the five prismatic colours least likely to be mistaken (the remaining two being less distinguishable, and not wanted, are best omitted) to be painted; and, in their natural order, on a width of eighteen inches and a depth of four, red, orange, yellow, green, blue; or, still to heighten the contrast, and render immediately successive apertures more distinguishable, red, green, orange, blue, yellow. The whole inner circle beneath and between the apertures to be painted black.

When the instrument is to be used, the index to be set to the signal apertures on the right. All the apertures to be covered or dark when it begins to be used, except that which is to give the signal. A signal gun to be fired to apprise the observer. If the index is set to the first aperture, it will denote that words are to be expressed; if to the second, that figures; if to the third, that the figures cease; and that the intelligence is carried on in words. When figures are to be expressed, the alternate apertures from the left are taken in their order, to denote from 1 to 10 inclusively;

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Telegraph. fively; the second from the right denotes 100; the fifth 1000. This order, and these intervals, are taken to prevent any confusion in so peculiarly important an article of the intelligence to be conveyed.

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p. 382.

Perhaps, however, none of the telegraphs hitherto offered to the public exceeds the following, either in simplicity, cheapness, or facility in working, and it might perhaps, with a few trifling additions, be made exceedingly distinct. It is thus described in the Repertory of Arts and Manufactures: For a nocturnal telegraph, let there be four large patent reflectors, lying on the same plane, parallel to the horizon, placed on the top of an observatory. Let each of these reflectors be capable, by means of two winches, either of elevation or depression to a certain degree. By elevating or depressing one or two of the reflectors, eighteen very distinct arrangements may be produced, as the following scheme will explain (A).

A	B	D	E	F	G
○	○	○	○	○	○
○○○	○ ○	○○ ○	○○○	○○○	○ ○

I	K	L	M	N	O
○○ ○	○○○	○○	○ ○	○ ○	○○
○	○	○○	○ ○	○○	○○

P	R	S	T	U	Y
○ ○	○○	○○	○	○ ○	○
○ ○	○ ○	○ ○	○○	○○	○○

For the sake of example, the above arrangements are made to answer to the most necessary letters of the alphabet; but alterations may be made at will, and a greater number of changes produced, without any addition to the reflectors. In the first observatory there need only be a set of single reflectors; but in the others each reflector should be double, so as to face both the preceding and subsequent observatory; and each observatory should be furnished with two telescopes. The proper diameter of the reflectors, and their distance from each other, will be ascertained by experience.

To convert this machine into a diurnal telegraph, nothing more is necessary than to insert, in the place of the reflectors, gilt balls, or any other conspicuous bodies.

Were telegraphs brought to so great a degree of perfection, that they could convey information speedily and distinctly; were they so much simplified, that they could be constructed and maintained at little expence—the advantages which would result from their use are almost inconceivable. Not to speak of the speed with which information could be communicated and orders given in time of war, by means of which misfortunes might be prevented or instantly repaired, difficulties removed, and disputes precluded, and by means of which the whole kingdom could be prepared in an instant to oppose an invading enemy; it might be used by commercial men to convey a commission cheaper and speedier than an express can travel. The capitals of distant nations might be united by chains of posts,

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and the settling of those disputes which at present take up months or years might then be accomplished in as many hours. An establishment of telegraphs might then be made like that of the post; and instead of being an expence, it would produce a revenue. Until telegraphs are employed to convey information that occurs very frequently, the persons who are stationed to work them will never become expert, and consequently will neither be expeditious nor accurate, though, with practice, there is no doubt but they will attain both in a degree of perfection of which we can as yet have but little conception.

TELEMACHUS, the son of Ulysses and Penelope, was still in the cradle when his father went with the rest of the Greeks to the Trojan war. At the end of this celebrated war, Telemachus, anxious to see his father, went to seek him; and as the place of his residence, and the cause of his long absence, were then unknown, he visited the court of Menelaus and Nestor to obtain information. He afterwards returned to Ithaca, where the suitors of his mother Penelope had conspired to murder him, but he avoided their snares; and by means of Minerva he discovered his father, who had arrived in the island two days before him, and was then in the house of Eumæus. With this faithful servant and Ulysses Telemachus concerted how to deliver his mother from the importunities of her suitors, and it was effected with great success. After the death of his father, Telemachus went to the island of Ææa, where he married Circe, or, according to others, Cassiphone the daughter of Circe, by whom he had a son called *Latinus*. He some time after had the misfortune to kill his mother-in-law Circe, and fled to Italy, where he founded Clusium. Telemachus was accompanied in his visit to Nestor and Menelaus by the goddess of wisdom under the form of Mentor. It is said that, when a child, Telemachus fell into the sea, and that a dolphin brought him safe to shore, after he had remained some time under water. From this circumstance Ulysses had the figure of a dolphin engraved on the seal which he wore on his ring.

From these stories, collected from Homer and the other poets of antiquity, the celebrated Fenelon archbishop of Cambray took the idea of his well-known *Adventures of Telemachus*; which, though not composed in verse, is justly intitled to be esteemed a poem. "The plan of the work (says Dr Blair) is in general well contrived; and is deficient neither in epic grandeur nor unity of object. The author has entered with much felicity into the spirit and ideas of the ancient poets, particularly into the ancient mythology, which retains more dignity, and makes a better figure in his hands than in those of any other modern poet. His descriptions are rich and beautiful; especially of the softer and calmer scenes, for which the genius of Fenelon was best suited; such as the incidents of pastoral life, the pleasures of virtue, or a country flourishing in peace. There is an inimitable sweetness and tenderness in several of the pictures of this kind which he has given:" and his measured prose, which is remarkably harmonious, gives the style nearly as much elevation as the French language is capable of supporting even in regular verse.

According to the same eminent critic, "the best executed part of the work is the first six books, in which Telemachus recounts his adventures to Calypso. The narration throughout them is lively and interesting. Afterwards, especially in the last twelve books, it becomes more tedious and languid; and in the warlike adventures which are at-

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tempted,

(A) Each reflector, after every arrangement, must be restored to its place.

Telephium, tempted, there is a great defect of vigour. The chief objection against this work being classed with epic poems, arises from the minute details of virtuous policy, into which the author in some places enters; and from the discourses and instructions of Mentor, which recur upon us too often, and too much in the strain of common-place morality. Though these were well suited to the main design of the author, which was to form the mind of a young prince, yet they seem not congruous to the nature of epic poetry; the object of which is to improve us by means of actions, characters, and sentiments, rather than by delivering professed and formal instruction."

TELEPHIUM, TRUE ORPINE, in botany: A genus of plants belonging to the class of *pentandria*, and order of *trigynia*; and in the natural system ranging under the 54th order, *Miscellanea*. The calyx is pentaphyllous; there are five petals, which are inserted into the receptacle; the capsule is unilocular and trivalvular. There are two species, the *imperati* and *oppositifolia*.

TELESCOPE, an optical instrument for viewing distant objects; so named by compounding the Greek words *τελε* *far off*, and *σκοπε* *to look at or contemplate*. This name is commonly appropriated to the larger sizes of the instrument, while the smaller are called **PERSPECTIVE-GLASSES**, **SPY-GLASSES**, **OPERA-GLASSES**. A particular kind, which is thought to be much brighter than the rest, is called a **NIGHT GLASS**.

To what has been said already with respect to the inventor of this most noble and useful instrument in the article **OPTICS**, we may add the two following claims.

Mr Leonhard Digges, a gentleman of the last century of great and various knowledge, positively asserts in his *Stratagems*, and in another work, that his father, a military gentleman, had an instrument which he used in the field, by which he could bring distant objects near, and could know a man at the distance of three miles. He says, that when his father was at home he had often looked through it, and could distinguish the waving of the trees on the opposite side of the Severn. Mr Digges resided in the neighbourhood of Bristol.

Francis Fontana, in his *Celestial Observations*, published at Naples in 1646, says, that he was assured by a Mr Hardy, advocate of the parliament of Paris, a person of great learning and undoubted integrity, that on the death of his father, there was found among his things an old tube, by which distant objects were distinctly seen; and that it was of a date long prior to the telescope lately invented, and had been kept by him as a secret.

It is not at all improbable, that curious people, handling spectacle glasses, of which there were by this time great varieties, both convex and concave, and amusing themselves with their magnifying power and the singular effects which they produced in the appearances of things, might sometimes chance so to place them as to produce distinct and enlarged vision. We know perfectly, from the table and scheme which Sirturus has given us of the tools or dishes in which the spectacle-makers fashioned their glasses, that they had convex lenses formed to spheres of 24 inches diameter, and of 11 inferior sizes. He has given us a scheme of a set which he got leave to measure belonging to a spectacle-maker of the name of *Rogette* at Cornuna in Spain; and he says that this man had tools of the same sizes for concave glasses. It also appears, that it was a general practice (of which we do not know the precise purpose) to use a convex and concave glass together. If any person should chance to put together a 24-inch convex and a 12-inch concave (wrought on both sides) at the distance of 6 inches, he

would have distinct vision, and the object would appear of double size. Concaves of 6 inches were not uncommon, and one such combined with the convex of 24, at the distance of 9 inches, would have distinct vision, and objects would be quadrupled in diameter. When such a thing occurred, it was natural to keep it as a curiosity, although the *rationale* of its operation was not in the least understood. We doubt not but that this happened much oftener than in these two instances. The chief wonder is, that it was not frequent, and taken notice of by some writer. It is pretty plain that Galileo's first telescope was of this kind, made up of such spectacle-glasses as he could procure; for it magnified only three times in diameter: a thing easily procured by such glasses as he could find with every spectacle-maker. And he could not but observe, in his trials of their glasses, that the deeper concaves and flatter convexes he employed, he produced the greater amplification; and then he would find himself obliged to provide a tool not used by the spectacle-makers, viz. either a much flatter tool for a convex surface, or a much smaller sphere for a concave: and, notwithstanding his telling us that it was by reflecting on the nature of refraction, and without any instruction, we are persuaded that he proceeded in this very way. His next telescope magnified but five times. Now the slightest acquaintance with the obvious laws of refraction would have directed him at once to a very small and deep concave, which would have been much easier made, and have magnified more. But he groped his way with such spectacle-glasses as he could get, till he at last made tools for very flat object-glasses and very deep eye-glasses, and produced a telescope which magnified about 25 times. Sirturus saw it, and took the measures of it. He afterwards saw a scheme of it which Galileo had sent to a German prince at In-spruch, who had it drawn (that is, the circles for the tools) on a table in his gallery. The object-glass was a plano-convex, a portion of a sphere, of 24 inches diameter; the eye-glass was a double concave of 2 inches diameter: the focal distances were therefore 24 inches and 1 inch nearly. This must have been a very lucky operation, for Sirturus says it was the best telescope he had seen; and we know that it requires the very best work to produce this magnifying power with such small spheres. Telescopes continued to be made in this way for many years; and Galileo, though keenly engaged in the observation of Jupiter's satellites, being candidate for the prize held out by the Dutch for the discovery of the longitude, and therefore much interested in the advantage which a convex eye-glass would have given him, never made them of any other form. Kepler published his *Dioptrics* in 1611; in which he tells us, all that he or others had discovered of the law of refraction, viz. that in very small obliquities of incidence, the angle of refraction was nearly $\frac{1}{4}$ of the angle of incidence. This was indeed enough to have pointed out, with sufficient exactness, the construction of every optical instrument that we are even now possessed of; for this proportionality of the angles of incidence and refraction is assumed in the construction of the optical figure for all of them; and the deviation from it is still considered as the *refinement* of the art, and was not brought to any rule till 50 years after by Huyghens, and called by him **ABERRATION**. Yet even the sagacious Kepler seems not to have seen the advantage of any other construction of the telescope; he just seems to acknowledge the possibility of it: and we are surprised to see writers giving him as the author of the astronomical telescope, or even as hinting at its construction. It is true, in the last proposition he shows how a telescope may be made *apparently* with a convex eye-glass: but this is only a frivolous fancy;

Telescope. fancy; for the eye-glass is directed to be made convex externally, and a very deep concave on the inside; so that it is, in fact, a meniscus with the concavity prevalent. In the 86th proposition, he indeed shows that it is possible so to place a convex glass behind another convex glass, that an eye shall see objects distinct, magnified, and inverted; and he speaks very sagaciously on the subject. After having said that an eye placed behind the point of union of the first glass will see an object inverted, he shows that a small part only will be seen; and then he shows that a convex glass, duly proportioned and properly placed, will show more of it. But in showing this, he speaks in a way which shows evidently that he had formed no distinct notions of the manner in which this effect would be produced, only saying vaguely that the convergency of the second glass would counteract the divergency beyond the focus of the first. Had he conceived the matter with any tolerable distinctness, after seeing the great advantage of taking in a field greater in almost any proportion, he would have eagerly caught at the thought, and enlarged on the immense improvement. Had he but drawn one figure of the progress of the rays through two convex glasses, such as fig. 12. of PL. CCCLXIV. the whole would have been open to his view.

This step, so easy and so important, was reserved for Father Scheiner, as has been already observed in the article OPTICS; and the construction of this author, together with that of Jansen, are the models on which all refracting telescopes are now constructed; and in all that relates to their magnifying power, brightness, and field of vision, they may be constructed on Kepler's principle, that the angles of refraction are in a certain given proportion to the angles of incidence.

But after Huyghens had applied his elegant geometry to the discovery of Snellius, viz. the proportionality, not of the angles, but of the sines, and had ascertained the aberrations from the foci of infinitely slender pencils, the reasons were clearly pointed out why there were such narrow limits affixed by nature to the performance of optical instruments, in consequence of the indistinctness of vision which resulted from constructions where the magnifying power, the quantity of light, or the field of vision, were extended beyond certain moderate bounds. The theory of aberrations, which that most excellent geometer established, has enabled us to diminish this indistinctness arising from any of these causes; and this diminution is the sole aim of all the different constructions which have been contrived since the days of Galileo and Scheiner.

THE description which has been already given of the various constructions of telescopes in the article OPTICS, is sufficient for instructing the reader in the general principles of their construction, and with moderate attention will show the manner in which the rays of light proceed, in order to ensure the different circumstances of amplification, brightness, and extent of field, and even distinctness of vision, in as far as this depends on the proper intervals between the glasses. But it is insufficient for giving us a knowledge of the improvements which are aimed at in the different departures from the original constructions of Galileo and Scheiner, the advantage of the double eye-glass of Huyghens, and the quintuple eye-glass of Dollond: still more is it insufficient for showing us why the highest degrees of amplification and most extensive field cannot be obtained by the mere proportion of the focal distances of the glasses, as Kepler had taught. In short, without the Huyghenian doctrine of aberrations, neither can the curious reader learn the limits of their performance, nor the artist learn why one telescope is better than another, or in what manner to proceed to make a te-

lescope differing in any particular from those which he serves. Telescope. vilely copies.

Although all the improvements in the construction of telescopes since the publication of Huyghens's Dioptrics have been the productions of this island, and although Dr Smith of Cambridge has given the most elegant and perspicuous account of this science that has yet appeared, we do not recollect a performance in the English language (except the Optics of Emerson) which will carry the reader beyond the mere schoolboy elements of the science, or enable a person of mathematical skill to understand or improve the construction of optical instruments. The last work on this subject of any extent (Dr Priestley's History of Vision) is merely a parlour book for the amusement of half-taught dilettanti, but is totally deficient in the mathematical part, although it is here that the science of optics has her chief claim to pre-eminence, and to the name of a DISCIPLINA ACCURATA. But this would have been *ultra crepidam*; and the author would in all probability have made as poor a figure here as he has done in his attempts to degrade his species in his Commentaries on the *Vibratiuncule* of Hartley; motions which neither the author nor his amplificator were able to understand or explain. We trust that our readers, jealous as we are of every thing that sinks us in the scale of nature's works, will pardon this transient ejaculation of spleen, when our thoughts are called to a system which, of *absolute and unavoidable necessity*, makes the DIVINE MIND nothing but a quivering of *that matter* of which it is the AUTHOR and unerring DIRECTOR. *Sed missum faciamus.*

We think therefore that we shall do the public some service, by giving such an account of this *higher branch* of optical science as will at least tend to the complete understanding of this noble instrument, by which our conceptions of the extent of almighty power, and wisdom, and beneficence, are so wonderfully enlarged. In the prosecution of this we hope that many general rules will emerge, by which artists who are not mathematicians may be enabled to construct optical instruments with intelligence, and avoid the many blunders and defects which result from mere servile imitation.

The general aim in the construction of a telescope is, to form, by means of mirrors or lenses, an image of the distant object, as large, as bright, and as extensive as is possible, consistently with distinctness; and then to view the image with a magnifying glass in any convenient manner. This gives us an arrangement of our subject. We shall first show the principles of construction of the object-glass or mirror, so as that it shall form an image of the distant object with these qualities; and then show how to construct the magnifying glass or eye-piece, so as to preserve them unimpaired.

This indistinctness which we wish to avoid arises from two causes; the spherical figures of the refracting and reflecting surfaces, and the different refrangibility of the differently coloured rays of light. The first may be called the SPHERICAL and the second the CHROMATIC indistinctness; and the deviations from the foci, determined by the elementary theorem (OPTICS, p. 289.), may be called the SPHERICAL and the CHROMATIC aberrations.

The limits of a Work like this will not permit us to give any more of the doctrine of aberrations than is absolutely necessary for the construction of achromatic telescopes; and we must refer the reader for a general view of the whole to Euler's *Dioptrics*, and other works of that kind. Dr Smith has given as much as was necessary for the comparison of the merits of different glasses of similar construction, and this in a very plain and elegant manner.

We shall begin with the aberration of colour, because it is the most simple.

Telescope.

Plate
Dii.

Let white or compounded light fall perpendicularly on the flat side PQ (fig. 1.) of a plano-convex lens PVQ, whose axis is CV and vertex V. The white ray pP falling on the extremity of the lens is dispersed by refraction at the point P of the spherical surface, and the red ray goes to the point r of the axis, and the violet ray to the point v . In like manner the white ray qQ is dispersed by refraction at Q, the red ray going to r , and the violet to v . The red ray Pr crosses the violet ray Qv in a point D, and Qr crosses Pv in a point E; and the whole light refracted and dispersed by the circumference, whose diameter is PQ, passes through the circular area, whose diameter is DE. Supposing that the lens is of such a form that it would collect red rays, refracted by its whole surface in the point r , and violet in the point v ; then it is evident that the whole light which occupies the surface of the lens will pass through this little circle, whose diameter is DE. Therefore white light issuing from a point so distant that the rays may be considered as parallel, will not be collected in another point or focus, but will be dispersed over the surface of that little circle; which is therefore called the *circle of chromatic dispersion*; and the radiant point will be represented by this circle. The neighbouring points are in like manner represented by circles; and these circles encroaching on and mixing with each other, must occasion haziness or confusion, and render the picture indistinct. This indistinctness will be greater in the proportion of the number of circles which are in this manner mixed together. This will be in the proportion of the room that is for them; that is, in proportion to the area of the circle, or in the duplicate proportion of its diameter. Our first business therefore is, to obtain measures of this diameter, and to mark the connection between it and the aperture and focal distance of the lens.

Let i be to r as the sine of incidence in glass to the sine of refraction of the red rays; and let i be to v as the sine of incidence to the sine of refraction of the violet rays. Then we say, that when the aperture PQ is moderate, $v - r : v + r - 2i = DE : PQ$, very nearly. For let DE, which is evidently perpendicular to Vr, meet the parallel incident rays in K and L and the radii of the spherical surface in G and H. It is plain that GPK is equal to the angle of incidence on the posterior or spherical surface of the lens; and GPr and GPv are the angles of refraction of the red and the violet rays; and that GK, GD, and GE, are very nearly as the sines of those angles, because the angles are supposed to be small. We may therefore institute this proportion $DE : KD = v - r : r - i$; then, by doubling the consequents $DE : 2KD = v - r : 2r - 2i$. Also $DE : 2KD + DE = v - r : 2r - 2i + v - r = v - r : r + v - 2i$. But $2KD + DE$ is equal to KL or PQ. Therefore we have $DE : PQ = v - r : r + v - 2i$. Q. E. D.

Cor. 1. Sir Isaac Newton, by most accurate observation, found, that in common glass the sines of refraction of the red and violet rays were 77 and 78 where the sine of incidence was 50. Hence it follows, that $v - r$ is to $v + r - 2i$ as 1 to 55; and that the diameter of the smallest circle of dispersion is $\frac{1}{55}$ th part of that of the lens.

2. In like manner may be determined the circle of dispersion that will comprehend the rays of any particular colour or set of colours. Thus all the orange and yellow will pass through a circle whose diameter is $\frac{1}{80}$ th of that of the lens.

3. In different surfaces, or plano-convex lenses, the angles of aberration rPv are as the breadth PQ directly, and as the focal distance VF inversely; because any angle DPE is as its subtense DE directly and radius DP inversely. N. B. we call VF the focal distance, because at this distance, or at the point F, the light is most of all consipated. If we examine the focal distance by holding the lens to the

sun, we judge it to be where the light is drawn into the Telescope's smallest spot.

When we reflect that a lens of $5\frac{1}{4}$ inches in diameter has a circle of dispersion $\frac{1}{55}$ th of an inch in diameter, we are surprised that it produces any picture of an object that can be distinguished. We should not expect greater distinctness from such a lens than would be produced in a camera obscura without a lens, by simply admitting the light through a hole of $\frac{1}{55}$ th of an inch in diameter. This, we know, would be very hazy and confused. But when we remark the superior vivacity of the yellow and orange light in comparison with the rest, we may believe that the effect produced by the confusion of the other colours will be much less sensible. But a stronger reason is, that the light is much denser in the middle of the circle of dispersion, and is exceedingly faint towards the margin. This, however, must not be taken for granted; and we must know distinctly the manner in which the light of different colours is distributed over the circle of chromatic dispersion, before we pretend to pronounce on the immense difference between the indistinctness arising from colour and that arising from the spherical figure. We think this the more necessary, because the illustrious discoverer of the chromatic aberration has made a great mistake in the comparison, because he did not consider the distribution of the light in the circle of spherical dispersion. It is therefore proper to investigate the chromatic distribution of the light with the same care that we bestowed on the spherical dispersion in OPTICS, n° 251. &c.; and we shall then see that the superiority of the reflecting telescope is incomparably less than Newton imagined it to be.

Therefore let EB (fig. 2.) represent a plano-convex lens, of which C is the centre and Cr the axis. Let us suppose it to have no spherical aberration, but to collect rays occupying its whole surface to single points in the axis. Let a beam of white or compounded light fall perpendicularly on its plane surface. The rays will be so refracted by its curved surface, that the extreme red rays will be collected at r , the extreme violet rays at w , and those of intermediate refrangibility at intermediate points, o, y, g, b, p, v , of the line rw , which is nearly $\frac{1}{55}$ th of rC . The extreme red and violet rays will cross each other at A and D; and AD will be a section or diameter of the circle of chromatic dispersion, and will be about $\frac{1}{55}$ th of EB. We may suppose wr to be bisected in b , because wb is to br very nearly in the ratio of equality (for $rb : rC = bA : cE = bA : cB = wb : wC$). The line rw will be a kind of prismatic spectrum, red from r to o , orange-coloured from o to y , yellow from y to g , green from g to b , blue from b to p , purple from p to v , and violet from v to w .

The light in its compound state must be supposed uniformly dense as it falls upon the lens; and the same must be said of the rays of any particular colour. Newton supposes also, that when a white ray, such as eE , is dispersed into its component coloured rays by refraction at E, it is uniformly spread over the angle DEA. This supposition is indeed gratuitous; but we have no argument to the contrary, and may therefore consider it as just. The consequence is, that each point w, v, p, b , &c. of the spectrum is not only equally luminous, but also illuminates uniformly its corresponding portion of AD: that is to say, the coating (so to term it) of any particular colour, such as purple, from the point p , is uniformly dense in every part of AD on which it falls. In like manner, the colouring of yellow, intercepted by a part of AD in its passage to the point y , is uniformly dense in all its parts. But the density of the different colours in AD is extremely different: for since the radiation in w is equally dense with that in p , the density of the violet colouring, which radiates from w , and is spread

Telescope—spread over the whole of AD, must be much less than the density of the purple colouring, which radiates from p , and occupies only a part of AD round the circle b . These densities must be very nearly in the inverse proportion of wb^2 to pb^2 .

Hence we see, that the central point b will be very intensely illuminated by the blue radiating from p and the green intercepted from bg . It will be more faintly illuminated by the purple radiating from vp , and the yellow intercepted from gy ; and still more faintly by the violet from wv , and the orange and red intercepted from yr . The whole colouring will be a white, tending a little to yellowness. The accurate proportion of these colourings may be computed from our knowledge of the position of the points o, y, g , &c. But this is of little moment. It is of more consequence to be able to determine the proportion of the total intensity of the light in b to its intensity in any other point I.

For this purpose draw IR, IwW , meeting the lens in R and W. The point I receives none of the light which passes through the space RW: for it is evident that $bI:CR = bA:CE$, $= 1:55$, and that $CR = CW$; and therefore, since all the light incident on EB passes through AB, all the light incident on RW passes through Ii (bi being made $= bI$). Draw oIO, yIY, gIG, IpP, IvV . It is plain, that I receives red light from RO, orange from OY, yellow from YG, green from GE, a little blue from BP, purple from PV, and violet from VW. It therefore wants some of the green and of the blue.

That we may judge of the intensity of these colours at I, suppose the lens covered with paper pierced with a small hole at G. The green light only will pass through I; the other colours will pass between I and b , or between I and A, according as they are more or less refrangible than the particular green at I. This particular colour converges to g , and therefore will illuminate a small spot round I, where it will be as much denser than it is at G as this spot is smaller than the hole at G. The natural density at G, therefore, will be to the increased density at I, as gI^2 to gG^2 , or as gb^2 to gC^2 , or as bI^2 to CG^2 . In like manner, the natural density of the purple coming to I through an equal hole at P will be to the increased density at I as bI^2 to CP^2 . And thus it appears, that the intensity of the differently coloured illuminations of any point of the circle of dispersion, is inversely proportional to the square of the distance from the centre of the lens to the point of its surface through which the colouring light comes to this point of the circle of dispersion. This circumstance will give us a very easy, and, we think, an elegant solution of the question.

Bisect CE in F, and draw FL perpendicular to CE, making it equal to CF. Through the point L describe the hyperbola KLN of the second order, that is, having the ordinates EK, EL, RN, &c. inversely proportional to the squares of the abscissæ CE, CF, CR, &c.; so that FL:RN

$= \frac{1}{CF^2} : \frac{1}{CR^2}$, or $= CR^2 : CF^2$, &c. It is evident that

these ordinates are proportional to the densities of the several coloured lights which go from them to any points whatever of the circle of dispersion.

Now the total density of the light at I depends both on the density of each particular colour and on the number of colours which fall on it. The ordinates of this hyperbola determine the first; and the space ER measures the number of colours which fall on I, because it receives light from the whole of ER, and of its equal BW. Therefore, if ordinates be drawn from any point of ER, their sum will be as the whole light which goes to I; that is, the total density of the light at I will be proportional to the area NREK.

Now it is known that $CE \times EK$ is equal to the infinitely extended area lying beyond EK; and $CR \times RN$ is equal to the infinitely extended area lying beyond RN. Therefore the area NREK is equal to $CR \times RN - CE \times EK$. But

RN and EK are respectively equal to $\frac{CF^2}{CR^2}$ and $\frac{CF^2}{CE^2}$. There-

fore the density at I is proportional to $CF^2 \times \left(\frac{CR}{CR^2} - \frac{CE}{CE^2} \right)$,

$= CF^2 \times \left(\frac{1}{CR} - \frac{1}{CE} \right) = CF^2 \times \frac{CE - CR}{CE \times CR} = CF^2 \times$

$\frac{ER}{CE \times CR} = \frac{CF^2}{CE} \times \frac{ER}{CR}$. But because CF is $\frac{1}{5}$ of CE,

$\frac{CF^2}{CE}$ is $= \frac{CF^2}{2CF} = \frac{CF}{2}$, a constant quantity. Therefore

the density of the light at I is proportional to $\frac{ER}{CR}$, or to $\frac{AI}{bI}$,

because the points R and I are similarly situated in EC and Ab.

Farther, if the semi-aperture CE of the lens be called

$\frac{CF^2}{1}$, $\frac{1}{2}$ is $= \frac{1}{8}$, and the density at I is $= \frac{AI}{8bI}$.

Here it is proper to observe, that since the point R has the same situation in the diameter EB that the point I has in the diameter AD of the circle of dispersion, the circle described on EB may be conceived as the magnified representation of the circle of dispersion. The point F, for instance, represents the point f in the circle of dispersion, which bisects the radius bA; and f receives no light from any part of the lens which is nearer the centre than F, being illuminated only by the light which comes through EF and its opposite BF'. The same may be said of every other point.

In like manner, the density of the light in f , the middle between b and A, is measured by $\frac{EF}{CF}$, which is $= \frac{EF}{EF}$, or 1.

This makes the density at this point a proper standard of comparison. The density there is to the density at I as 1

to $\frac{AI}{bI}$, or as bI to AI ; and this is the simplest mode of comparison. The density half way from the centre of the circle of dispersion is to the density at any point I as bI to IA .

Lastly, through L describe the common rectangular hyperbola kLn , meeting the ordinates of the former in k, L , and n : and draw kb parallel to EC, cutting the ordinates in g, f, r , &c. Then $CR:CE = Ek:Rn$, and $CR:CE - CR = Ek:Rn - Ek$, or $CR:RE = Ek:rn$, and $bI:IA = Ek:rn$. And thus we have a very simple expression of the density in any point of the circle of dispersion. Let the point be anywhere, as at I. Divide the lens in R as AD is divided in I, and then rn is as the density in I.

These two measures were given by Newton; the first in his *Treatise de Mundi Syllemate*, and the last in his *Optics*; but both without demonstration.

If the hyperbola kLn be made to revolve round the axis CQ, it will generate a solid spindle, which will measure the whole quantity of light which passes through different portions of the circle of dispersion. Thus the solid produced by the revolution of Lkf will measure all the light which occupies the outer part of the circle of dispersion lying without the middle of the radius. This space is $\frac{1}{2}$ ths of the whole circle; but the quantity of light is but $\frac{1}{4}$ th of the whole.

A still more simple expression of the whole quantity of light passing through different portions of the circle of chromatic dispersion may now be obtained as follows:

It has been demonstrated, that the density of the light at

Telescope.

I is as $\frac{AI}{bI}$, or as $\frac{ER}{CR}$. Suppose the figure to turn round the axis. I or R describe circumferences of circles; and the whole light passing through this circumference is as the circumference, or as the radius, and as the density jointly.

It is therefore as $\frac{ER}{CR} \times CR$, that is, as ER. Draw any straight line Em, cutting RN in s, and any other ordinate FL in xRs. The whole light which illuminates the circumference described by I is to the whole light which illuminates the centre b as ER to EC, or as Rs to Cm. In like manner, the whole light which illuminates the circumference described by the point f in the circle of dispersion is to the whole light which illuminates the centre b, as Fx to Cm. The lines Cm, RS, Fx, are therefore proportional to the whole light which illuminates the corresponding circumferences in the circle of dispersion. Therefore the whole light which falls on the circle whose radius is bI, will be represented by the trapezium in CRS; and the whole light which falls on the ring described by IA, will be represented by the triangle E s R; and so of any other portions.

By considering the figure, we see that the distribution of the light is exceedingly unequal. Round the margin it has no sensible density; while its density in the very centre is incomparably greater than in any other point, being expressed by the asymptote of a hyperbola. Also the circle described with the radius $\frac{Ab}{2}$ contains $\frac{1}{4}$ ths of the whole light.

No wonder then that the confusion caused by the mixture of these circles of dispersion is less than one should expect; besides, it is evident that the most lively or impressive colours occupy the middle of the spectrum, and are there much denser than the rest. The margin is covered with an illumination of deep red and violet, neither of which colours are brilliant. The margin will be of a dark claret colour. The centre revives all the colours, but in a proportion of intensity greatly different from that in the common prismatic spectrum, because the radiant points L, p, b, g, &c. by which it is illuminated, are at such different distances from it. It will be white; but we apprehend not a pure white, being greatly overcharged with the middle colours.

These considerations show that the coloured fringes, which are observed to border very luminous objects seen on a dark ground through optical instruments, do not proceed from the object-glass of a telescope or microscope, but from an improper construction of the eye-glasses. The chromatic dispersion would produce fringes of a different colour, when they produce any at all, and the colours would be differently disposed. But this dispersion by the object-glass can hardly produce any fringes: its effect is a general and almost uniform mixture of circles all over the field, which produces an uniform haziness, as if the object were viewed at an improper distance, or out of its focus, as we vulgarly express it.

We may at present form a good guess at the limit which this cause puts to the performance of a telescope. A point of a very distant object is represented, in the picture formed by the object-glass, by a little circle, whose diameter is at least $\frac{1}{300}$ th of the aperture of the object-glass, making a very full allowance for the superior brilliancy and density of the central light. We look at this picture with a magnifying eye-glass. This magnifies the picture of the point. If it amplify it to such a degree as to make it an object individually distinguishable, the confusion is then sensible. Now this can be computed. An object subtending one minute of a degree is distinguished by the dullest eye, even although it be a dark object on a bright ground. Let us therefore sup-

pose a telescope, the object-glass of which is of six feet focal distance, and one inch aperture. The diameter of the circle of chromatic dispersion will be $\frac{1}{300}$ th of an inch, which subtends at the centre of the object-glass an angle of about $9\frac{1}{2}$ seconds. This, when magnified six times by an eye-glass, would become a distinguishable object; and a telescope of this length would be indistinct if it magnified more than six times, if a point were thus spread out into a spot of uniform intensity. But the spot is much less intense about its margin. It is found experimentally that a piece of engraving, having fine cross hatches, is not sensibly indistinct till brought so far from the limits of perfectly distinct vision, that this indistinctness amounts to 6' or 5' in breadth.—Therefore such a telescope will be sensibly distinct when it magnifies 36 times; and this is very agreeable to experience.

We come, in the second place, to the more arduous task of ascertaining the error arising from the spherical figure of the surfaces employed in optical instruments.—Suffice it to say, before we begin, that although geometers have exhibited other forms of lenses which are totally exempt from this error, they cannot be executed by the artist; and we are therefore restricted to the employment of spherical surfaces.

Of all the determinations which have been given of spherical aberration, that by Dr Smith, in his Optics, which is an improvement of the fundamental theorem of that most elegant geometer Huyghens, is the most perspicuous and palpable. Some others are more concise, and much better fitted for after use, and will therefore be employed by us in the prosecution of this article. But they do not keep in view the optical facts, giving the mind a picture of the progress of the rays, which it can contemplate and discover amidst many modifying circumstances. By ingenious substitutions of analytical symbols, the investigation is rendered expeditious, concise, and certain; but these are not immediate symbols of things, but of operations of the mind; objects sufficiently subtle of themselves, and having no need of substitutions to make us lose sight of the real subject; and thus our occupation degenerates into a process almost without ideas. We shall therefore set out with Dr Smith's fundamental Theorem.

1. In Reflections.

Let AVB (fig. 3.) be a concave spherical mirror, of which C is the centre, V the vertex, CV the axis, and F the focus of an infinitely slender pencil of parallel rays passing through the centre. Let the ray aA, parallel to the axis, be reflected in AG, crossing the central ray CV in f. Let AP be the sine of the semi-aperture AV, AD its tangent, and CD its secant.

The aberration Ff from the principal focus of central rays is equal to $\frac{1}{2}$ of the excess VD of the secant above the radius, or very near equal to $\frac{1}{2}$ of VP, the versed sine of the semi-aperture.

For because AD is perpendicular to CA, the points C, A, D, are in a circle, of which CD is the diameter; and because Af is equal to Cf, by reason of the equality of the angles fAC, fCA, and CAa, f is the centre of the circle through C, A, D, and fD is $= \frac{1}{2}$ CD. But FC is $= \frac{1}{2}$ CV. Therefore Ff is $\frac{1}{2}$ of VD.

But because DV : VP = DC : VC, and DC is very little greater than VC when the aperture AB is moderate, DV is very little greater than VP, and Ff is very nearly equal to $\frac{1}{2}$ of VP.

Cor. 1. The longitudinal aberration is $= \frac{AV^2}{4CV}$, for PV is very nearly $= \frac{AV^2}{2CV}$.

Cor. 2.

Telescope.

Telescope.

Cor. 2. The lateral aberration FG is $= \frac{AV^3}{2CV^2}$. For $FG : Ff = AP : Pf = AV : \frac{1}{2} CV$ nearly, and therefore $FG = \frac{AV^3}{4CV} \times \frac{2}{CV} = \frac{AV^3}{2CV^2}$.

2. In Refractions.

Let AVB (fig. 4. A or B) be a spherical surface separating two refracting substances, C the centre, V the vertex, AV the semi aperture, AP its sine, PV its versed sine, and F the focus of parallel rays infinitely near to the axis. Let the extreme ray aA , parallel to the axis, be refracted into AG , crossing CF in f , which is therefore the focus of extreme parallel rays.

The rectangle of the sine of incidence, by the difference of the sines of incidence and refraction, is to the square of the sine of refraction, as the versed sine of the semi-aperture is to the longitudinal aberration of the extreme rays.

Call the sine of incidence i , the sine of refraction r , and their difference d .

Join CA , and about the centre f describe the arch AD .

The angle ACV is equal to the angle of incidence, and CAf is the angle of refraction. Then, since the sine of incidence is to the sine of refraction as VF to CF , or as Af to Cf , that is, as Df to Cf , we have

$$CF : FV = Cf : fD$$

by conversion $CF : CV = Cf : CD$

altern. conver. $CF - Cf : CV - CD = CF : CV$

or $Ff : VD = CF : CV = r : d$.

Now $PV = \frac{AP^2}{CP + CV} = \frac{AP^2}{2CV}$ nearly, and $PD = \frac{AP^2}{fP + fV}$

$= \frac{AP^2}{2fV}$ nearly, $= \frac{AP^2}{2FV}$ nearly. Therefore $PV : PD$

$= FV : CV$, and $DV : PV = CF : FV$ nearly.

We had above $Ff : VD = r : d$;

and now $VD : PV = CF : FV = r : i$;

therefore $Ff : PV = r^2 : di$,

and $Ff = \frac{r^2}{di} \times PV$. Q. E. D.

The aberration will be different according as the refraction is made towards or from the perpendicular; that is, according as r is less or greater than i . They are in the ratio of $\frac{r^2}{di}$ to $\frac{i^2}{dr}$, or of r^3 to i^3 . The aberration therefore is always much diminished when the refraction is made from a rare into a dense medium. The proportion of the sines for air and glass is nearly that of 3 to 2. When the light is refracted into the glass, the aberration is nearly $\frac{4}{3}$ of PV ; and when the light passes out of glass into air, it is about $\frac{2}{3}$ of PV .

Cor. 1. $Ff = \frac{r^2}{di} \times \frac{AP^2}{2CV}$ nearly, and it is also $= \frac{r^2}{d^2} \times \frac{AP^2}{2FV}$, because $PV = \frac{AP^2}{2CV}$ nearly, and $i : d = FV : CV$.

Cor. 2. Because $fP : PA = Ff : FG$

or $FV : AV = Ff : FG$ nearly,

we have FG , the lateral aberration, $= Ff \times \frac{AV}{FV} = \frac{r^2}{d^2}$

$\times \frac{AV^3}{2FV^2} = \frac{r^2}{i^2} \times \frac{AV^3}{2CV^2}$.

Cor. 3. Because the angle $F \cdot Af$ is proportional to $\frac{FG}{FV}$ very

nearly, we have the angular aberration $FAf = \frac{r^2}{d^2} \times$

$\frac{AV^3}{2FV^3} = \frac{r^2}{i^2} \times \frac{AV^3}{2CV^3}$.

In general, the longitudinal aberrations from the focus of central parallel rays are as the squares of the apertures directly, and as the focal distances inversely; and the lateral aberrations are as the cubes of the apertures directly, and the squares of the focal distances inversely; and the angular aberrations are as the cubes of the aperture directly, and the cubes of the focal distances inversely.

The reader must have observed, that to simplify the investigation, some small errors are admitted. PV and PD are not in the exact proportion that we assumed them, nor is Df equal to FV . But in the small apertures which suffice for optical instruments, these errors may be disregarded.

This spherical aberration produces an indistinctness of vision, in the same manner as the chromatic aberration does, viz. by spreading out every mathematical point of the object into a little spot in its picture; which spots, by mixing with each other, confuse the whole. We must now determine the diameter of the circle of diffusion, as we did in the case of chromatic dispersion.

Let a ray $\beta\alpha$ (fig. 5.) be refracted on the other side of the axis, into αH , cutting AfG in H , and draw the perpendicular EH . Call AV a , αV α , Vf (or VF , or $V\phi$, which in this comparison may be taken as equal) $= f$, $Ff = b$, and $fE = \phi x$.

$AV^2 : \alpha V^2 = Ff : F\phi$ (already demonstrated) and $F\phi = \frac{\alpha^2}{a^2} b$, and $Ff - F\phi$, (or $f\phi$) $= b - \frac{\alpha^2}{a^2} b = \frac{a^2 b - \alpha^2 b}{a^2}$,

$= \frac{b}{a^2} \times a^2 - \alpha^2 = \frac{b}{a^2} \times a + \alpha \times a - \alpha$. Also $Pf : PA$

$= fE : EH$, or $f : a = x : \frac{a x}{f} = EH$. And $P\pi : P\phi =$

$EH : E\phi$, or $\alpha : f = \frac{a x}{f} : \frac{a x}{\alpha} = E\phi$. Therefore $f\phi =$

$\frac{a x}{\alpha} + x = \frac{a + \alpha x}{\alpha} = \frac{x}{\alpha} \times a + \alpha$. Therefore $\frac{x}{\alpha} \times a + \alpha =$

$\frac{b}{a^2} \times a + \alpha \times a - \alpha$, and $\frac{x}{\alpha} = \frac{b}{a^2} \times a - \alpha$, and $x = \frac{b}{a^2} \times \alpha$

$(a - \alpha)$. Therefore x is greatest when $\alpha \times a - \alpha$ is greatest; that is, when $\alpha = \frac{1}{2} a$. Therefore EH is greatest when $P\pi$ is equal to the half of AP . When this is the case, we

have at the same time $\frac{b}{a^2} \times \alpha (a - \alpha) = \frac{b}{a^2} \times \frac{1}{4} a^2$, and x

$= \frac{1}{4} b$, or $EH = \frac{1}{4} FG$. That is, the diameter of the circle of aberration through which the whole of the refracted light

must pass, is $\frac{1}{4}$ of the diameter of the circle of aberration at the focus of parallel central rays. In the chromatic aberration it was $\frac{1}{2}$; so that in this respect the spherical aberration does not create so great confusion as the chromatic.

We are now able to compare them, since we have now the measure of both the circles of aberration.

It has not been found possible to give more than four inches of aperture to an object glass of 100 feet focal distance, so as to preserve sufficient distinctness. If we compute the diameter of the circle EH corresponding to this

aperture, we shall find it not much to exceed $\frac{1}{120,000}$ of an

inch. If we restrict the circle of chromatic dispersion to $\frac{1}{250}$ of the aperture, which is hardly the fifth part of the

whole dispersion in it, it is $\frac{1}{62\frac{1}{2}}$ of an inch, and is about

1900 times greater than the other.

The circle of spherical aberration of a plano-convex lens, with the plane side next the distant object, is equal to the circle of chromatic dispersion when the semi-aperture is about

Plate
DIII.

Telescope about 15° : For we saw formerly that EH is $\frac{1}{2}$ of FG, and that FG is $= \frac{r^2}{i^2} \frac{AP^3}{2AC^2}$, and therefore $EG = \frac{r^2}{i^2} \times \frac{AP^3}{8AC^2}$.

This being made $= \frac{AP}{55}$, gives us $AP = \sqrt{\frac{8i^2 AC^2}{55r^2}}$,

which is nearly $\frac{AC}{4}$, and corresponds to an aperture of 30° diameter, if r be to i as 3 to 2.

Sir Isaac Newton was therefore well entitled to say, that it was quite needless to attempt figures which should have less aberration than spherical ones, while the confusion produced by the chromatic dispersion remained uncorrected. Since the indistinctness is as the squares of the diameters of the circles of aberration, the disproportion is quite beyond our imagination, even when Newton has made such a liberal allowance to the chromatic dispersion. But it must be acknowledged, that he has not attended to the distribution of the light in the circle of spherical aberration, and has hastily supposed it to be like the distribution of the coloured light, indefinitely rare in the margin, and denser in the centre.

We are indebted to Father Boscovich for the elegant determination of this distribution, which we have given in the article OPTICS. From this it appears, that the light in the margin of the circle of spherical aberration, instead of being incomparably rarer than in the spaces between it and the centre, is incomparably denser. The indistinctness therefore produced by the intersection of these luminous circumferences is vastly great, and increases the whole indistinctness exceedingly. By a gross calculation which we made, it appears to be increased at least 500 times. The proportional indistinctness therefore, instead of being 1900^2

to 1, is only $\frac{1900^2}{500}$, or nearly 7220 to 1; a proportion still sufficiently great to warrant Newton's preference of the reflecting telescope of his invention. And we may now observe, that the reflecting telescope has even a great advantage over a refracting one of the same focal distance, with respect to its spherical aberration: For we have seen (Cor.

2.) that the lateral aberration is $\frac{r^2}{i^2} \frac{AV^3}{2CV^2}$. This for a plano-convex glass is nearly $\frac{9}{4} \frac{AV^3}{2CV^2}$. And the diameter of the

circle of aberration is one-fourth of this, or $\frac{9}{16} \times \frac{AV^3}{2CV^2}$.

In like manner, the lateral aberration of a concave mirror is $\frac{AV^3}{2CV^2}$; and the diameter of the circle of dispersion is

$\frac{AV^3}{8CV^2}$; and therefore if the surfaces were portions of the same sphere, the diameter of the circle of aberration of refracted rays would be to that of the circle of aberration of reflected rays as $\frac{9}{8}$ to $\frac{1}{4}$, or as 9 to 4. But when the refracting and reflecting surfaces, in the position here considered, have the same focal distance, the radius of the refracting surface is four times that of the reflecting surface. The proportion of the diameters of the circles of spherical aberration is that of 9×4^2 to 4, or of 144 to 4, or 36 to 1. The distinctness therefore of the reflector is 36×36 , or 1296 times greater than that of a plano-convex lens (placed with the plane side next the distant object) of the same breadth and focal distance, and will therefore admit of a much greater magnifying power. This comparison is indeed made in circumstances most favourable to the reflector, because this is the very worst position of a plano-convex lens. But we have not as yet learned the aberration in any

other position. In another position the refraction and consequent aberration of both surfaces are complicated.

Before we proceed to the consideration of this very difficult subject, we may deduce from what has been already demonstrated several general rules and maxims in the construction of telescopes, which will explain (to such readers as do not wish to enter more deeply into the subject), and justify the proportion which long practice of the best artists has functioned.

Indistinctness proceeds from the commixture of the circles of aberration on the retina of the eye: For any one sensible point of the retina, being the centre of a circle of aberration, will at once be affected by the admixture of the rays of as many different pencils of light as there are sensible points in the area of that circle, and will convey to the mind a mixed sensation of as many visible points of the object. This number will be as the area of the circle of aberrations, whatever be the size of a sensible point of the retina. Now in vision with telescopes, the diameter of the circle of aberration on the retina is as the apparent magnitude of the diameter of the corresponding circle in the focus of the eye-glass; that is, as the angle subtended by this diameter at the centre of the eye-glass; that is, as the diameter itself directly, and as the focal distance of the eye-glass inversely. And the area of that circle on the retina is as the area of the circle in the focus of the eye-glass directly, and as the square of the focal distance of the eye-glass inversely. And this is the measure of the apparent indistinctness.

Cor. In all sorts of telescopes, and also in compound microscopes, an object is seen equally distinct when the focal distance of the eye-glasses are proportional to the diameters of the circles of aberration in the focus of the object-glass.

Here we do not consider the trifling alteration which well constructed eye-glasses may add to the indistinctness of the first image.

In refracting telescopes, the apparent indistinctness is as the area of the object-glass directly, and as the square of the focal distance of the eye-glass inversely. For it has been shown, that the area of the circle of dispersion is as the area of the object-glass, and that the spherical aberration is insignificant when compared with this.

Therefore, to make reflecting telescopes equally distinct, the diameter of the object-glass must be proportional to the focal distance of the eye-glass.

But in reflecting telescopes, the indistinctness is as the sixth power of the aperture of the object-glass directly, and as the fourth power of the focal distance of the object-glass and square of the focal distance of the eye-glass inversely. This is evident from the dimensions of the circle of aberration, which was found proportional to $\frac{AV^3}{CV^2}$.

Therefore, to have them equally distinct, the cubes of the apertures must be proportional to the squares of the focal distance multiplied by the focal distance of the eye-glass.

By these rules, and a standard telescope of approved goodness, an artist can always proportion the parts of any instrument he wishes to construct. Mr Huyghens made one, of which the object-glass had 30 feet focal distance and three inches diameter. The eye-glass had 3.3 inches focal distance. And its performance was found superior to any which he had seen; nor did this appear owing to any chance goodness of the object-glass, because he found others equally good which were constructed on similar proportions. This has therefore been adopted as a standard.

It does not at first appear how there can be any difficulty

Telescope. ty in this matter, because we can always diminish the aperture of the object-glass or speculum till the circle of aberration is as small as we please. But by diminishing this aperture, we diminish the light in the duplicate ratio of the aperture. Whatever be the aperture, the brightness is diminished by the magnifying power, which spreads the light over a greater surface in the bottom of the eye. The apparent brightness must be as the square of the aperture of the telescope directly, and the square of the amplification of the diameter of an object inversely. Objects therefore will be seen equally bright if the apertures of the telescopes be as the focal distances of the object-glasses directly, and the focal distances of the single eye-glass (or eye-glass equivalent to the eye-piece) inversely. Therefore, to have telescopes equally distinct and equally bright, we must combine these proportions with the former. It is needless to go farther into this subject, because the construction of refracting telescopes has been so materially changed by the correction of the chromatic aberration, that there can hardly be given any proportion between the object-glass and eye-glasses. Every thing now depends on the degree in which we can correct the aberrations of the object-glass. We have been able so far to diminish the chromatic aberration, that we can give very great apertures without its becoming sensible. But this is attended with so great an increase of the aberration of figure, that this last becomes a sensible quality. A lens which has 30° for its semi-aperture, has a circle of aberration equal to its chromatic aberration. Fortunately we can derive from the very method of contrary refractions, which we employ for removing the chromatic aberration, a correction of the other. We are indebted for this contrivance also to the illustrious Newton.

We call this Newton's contrivance, because he was the first who proposed a construction of an object-glass in which the aberration was corrected by the contrary aberrations of glass and water.

Huyghens had indeed supposed, that our all-wise Creator had employed in the eyes of animals many refractions in place of one, in order to make the vision more distinct; and the invidious detractors from Newton's fame have caught at this vague conjecture as an indication of his knowledge of the possibility of destroying the aberration of figure by contrary refractions. But this is very ill-founded. Huyghens has acquired sufficient reputation by his theory of aberrations. The scope of his writing in the passage alluded to, is to show that, by dividing any intended refraction into parts, and producing a certain convergence to or divergence from the axis of an optical instrument by means of two or three lenses instead of one, we diminish the aberrations four or nine times. This conjecture about the eye was therefore in the natural train of his thoughts. But he did not think of destroying the aberration altogether by opposite refractions. Newton, in 1669, says, that opticians need not trouble themselves about giving figures to their glasses other than spherical. If this figure were all the obstacle to the improvement of telescopes, he could show them a construction of an object-glass having spherical surfaces where the aberration is destroyed; and accordingly gives the construction of one composed of glass and water, in which this is done completely by means of contrary refractions.

The general principle is this: When the radiant point R (fig. 5. B), or focus of incident rays, and its conjugate focus F of refracted central rays, are on opposite sides of the refracting surface or lens V, the conjugate focus f of marginal rays is nearer to R than F is. But when the focus of incident rays R' lies on the same side with its conjugate focus F' for central rays, R' f is greater than R' F'.

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Now fig. 5. C represents the contrivance for destroying the colour produced at F, the principal focus of the convex lens V, of crown glass, by means of the contrary refraction of the concave lens v of flint glass. The incident parallel rays are made to converge to F by the first lens. This convergence is diminished, but not entirely destroyed, by the concave lens v , and the focus is formed in F. F and F' therefore are conjugate foci of the concave lens. If F be the focus of V for central rays, the marginal rays will be collected at some point f nearer to the lens. If F be now considered as the focus of light incident on the centre of v , and F' be the conjugate focus, the marginal ray p F would be refracted to some point f' lying beyond F'. Therefore the marginal ray p f may be refracted to F', if the aberration of the concave be properly adjusted to that of the convex.

This brings us to the most difficult part of our subject, the compounded aberrations of different surfaces. Our limits will not give us room for treating this in the same elementary and perspicuous manner that we employed for a single surface. We must try to do it in a compendious way, which will admit at once the different surfaces and the different refractive powers of different substances. This must naturally render the process more complicated; but we hope to treat the subject in a way easily comprehended by any person moderately acquainted with common algebra; and we trust that our attempt will be favourably received by an indulgent public, as it is (as far as we know) the only dissertation in our language on the construction of achromatic instruments. We cannot but express our surprise at this indifference about an invention which has done so much honour to our country, and which now constitutes a very lucrative branch of its manufacture. Our artists infinitely surpass all the performances of foreigners in this branch, and supply the markets of Europe without any competition; yet it is from the writings on the continent that they derive their scientific instruction, and particularly from the dissertations of Clairaut, who has wonderfully simplified the analysis of optical propositions. We shall freely borrow from him, and from the writings of Abbé Boscovich, who has considerably improved the first views of Clairaut. We recommend the originals to the curious reader. Clairaut's dissertations are to be found in the Memoirs of the Academy of Paris, 1756, &c.; those of Boscovich in the Memoirs of the Academy of Bologna, and in his five volumes of *Opuscula*, published at Bassano in 1785. To these may be added D'Alembert and Euler. The only thing in our language is the translation of a very imperfect work by Schærfer.

Lemma 1. In the right-angled triangle MXS (fig. 6.), of which one side MX is very small in comparison of either of the others; the excess of the hypotenuse MS, above the side XS, is very nearly equal to $\frac{MX^2}{2MS}$ or to $\frac{MX^2}{2XS}$. For if about the centre S, with the radius SM, we describe the semicircle AMO, we have $AX \times XO = MX^2$. Now $AX = MS - SX$, and XO, is nearly equal to $2MS$ or $2XS$; on the other hand, MS is nearly equal to $XS + \frac{MX^2}{2XS}$; and in like manner MG is nearly equal to $\frac{MX^2}{2XG} + XG$, and MH is nearly equal to $\frac{MX^2}{2XH} + XH$.

PROP. I. Let the ray m M, incident on the spherical surface AM, converge to G; that is, let G be the focus of inci.

Telescope incident rays. It is required to find the focus F of refracted rays?

Let m express the ratio of the sine of incidence and refraction; that is, let m be to 1 as the sine of incidence to the sine of refraction in the substance of the sphere.

Then $MG : GS = \sin. MSH : \sin. SMG$,
and $m : 1 = \sin. SMG : \sin. SMH$;
therefore $m \times MG : GS = \sin. MSH : \sin. SMH$.
Now $S, MSH : S, SMH = MH : HS$. Therefore, finally,
 $m. MG : GS = MH : HS$.

Now let MS , the radius of the refracting surface, be called a . Let AG , the distance of the focus of incident rays from the surface, be called r . And let AH , the focal distance of refracted rays, be called x . Lastly, let the sine MX of the semi-aperture be called e . Observe, too, that a, r, x , are to be considered as positive quantities, when AS, AG, AH , lie from the surface in the direction in which the light is supposed to move. If therefore the refracting surface be concave, that is, having the centre on that side from which the light comes; or if the incident rays are divergent, or the refracted rays are divergent; then a, r, x , are negative quantities.

It is plain that $HS = x - a$; $GS = r - a$; also $AX = \frac{e^2}{2a}$ nearly. $HX = a - \frac{e^2}{2a}$. $GX = r - \frac{e^2}{2a}$. Now add to HX and to GX their differences from MH and MG , which (by the Lemma) are $\frac{e^2}{2x}$ and $\frac{e^2}{2r}$. We get $MH = x - \frac{e^2}{2a} + \frac{e^2}{2x}$, and $MG = r - \frac{e^2}{2a} + \frac{e^2}{2r}$. In order to shorten our notation, make $k = \frac{1}{a} - \frac{1}{r}$. This will make $MG = r - \frac{ke^2}{2}$.

Now substitute these values in the final analogy at the top of this column, viz. $MH : HS = m. MG : GS$; it becomes $x - \frac{e^2}{2a} + \frac{e^2}{2x} : x - a = m r - \frac{m k e^2}{2} : r - a$ (or ark), because $k = \frac{r - a}{ar}$, and $ark = r - a$. Now multiply the extreme and mean terms of this analogy. It is evident that it must give us an equation which will give us a value of x or AH , the quantity sought.

But this equation is quadratic. We may avoid the solution by an approximation which is sufficiently accurate, by substituting for x in the fraction $\frac{e^2}{2x}$ (which is very small in all cases of optical instruments), an approximate value very easily obtained, and very near the truth. This is the focal distance of an infinitely slender pencil of rays converging to G . This we know by the common optical theorem to be $\frac{amr}{m - 1 - r/a}$. Let this be called φ ; if we substitute

k in place of $\frac{1}{a} - \frac{1}{r}$, this value of φ becomes $= \frac{am}{m - ak}$.

This gives us, by the by, an easily remembered expression (and beautifully simple) of the refracted focus of an infinitely slender pencil, corresponding to any distance r of the radiant point. For since $\varphi = \frac{am}{m - ak}$, $\frac{1}{\varphi}$ must be $=$

$\frac{m - ak}{am} = \frac{m}{am} - \frac{ak}{am} = \frac{1}{a} - \frac{k}{m}$. We may even express it

more simply, by expanding k , and it becomes $\frac{1}{\varphi} = \frac{1}{a} - \frac{1}{ma}$ Telescope

$= \frac{1}{mr}$.

Now put this value of $\frac{1}{\varphi}$ in place of the $\frac{1}{x}$ in the analogy employed above. The first term of the analogy becomes

$x - \frac{e^2}{2a} + \frac{e^2}{2a} - \frac{ke^2}{2m}$, or $x - \frac{ke^2}{2m}$. The analogy now becomes $x - \frac{ke^2}{2m} : x - a = m r - \frac{m k e^2}{2} : ark$. Hence we obtain the

linear equation $mr x - \frac{m k e^2 x}{2} - m r a + \frac{m k a e^2}{2} = ark x - \frac{ark e^2}{2m}$; from which we finally deduce

$$x = \frac{m r a - \frac{1}{2} m a k e^2 - \frac{ark^2 e^2}{2m}}{m r - ark - \frac{1}{2} m k e^2}$$

We may simplify this greatly by attending to the elementary theorem in fluxions, that the fraction $\frac{x + \dot{x}}{y + \dot{y}}$ differs

from the fraction $\frac{x}{y}$ by the quantity $\frac{y\dot{x} - x\dot{y}}{y^2}$; this being the

fluxion of $\frac{x}{y}$. Therefore $\frac{x + \dot{x}}{y + \dot{y}} = \frac{x}{y} + \frac{y\dot{x} - x\dot{y}}{y^2}$. Now the preceding formula is nearly in this situation. It may

be written thus; $\frac{m r a - (\frac{1}{2} m a k e^2 - \frac{ark^2 e^2}{2m})}{m r - ark - m k e^2}$, when the last terms of the numerator and denominator are very small in comparison with the first, and may be considered as the $\dot{x}$ and $\dot{y}$, while $m r a$ is the x , and $m r - ark$ is the y . Treating it in this way, it may be stated thus:

$$x = \frac{m r a}{m r - ark} + \frac{(m r a) \frac{1}{2} m k e^2 - (m r - ark) (\frac{1}{2} m k a e^2 + \frac{ark^2 e^2}{2m})}{r^2 (m - ak)^2}$$

$$\text{or } x = \frac{m r a}{r (m - ak)} + \frac{(m r a) m k - (m r - ark) (m k a + \frac{ark^2}{m})}{r^2 (m - ak)^2} \times \frac{1}{2} e^2.$$

The first term $\frac{m r a}{r (m - ak)}$, or $\frac{m a}{m - ak}$, is evidently $= \varphi$, the focal distance of an infinitely slender pencil. Therefore the aberration is expressed by the second term, which we must endeavour to simplify.

If we now perform the multiplications indicated by $(m r - ark) \times (m k a - \frac{ark^2}{m})$, it is plain that $-m r \times m k a$ destroys the first term $m r a \times m k$ of the numerator of our small fraction, and there remains of this numerator $(m a^2 r k^2 - a r^2 k^2 + \frac{a^2 r^2 k^3}{m}) \frac{1}{2} e^2$, which is equal to $m^2 a^2 (\frac{r k^2}{m} - \frac{r^2 k^2}{m^2 a} + \frac{r^2 k^2}{m^3}) \frac{1}{2} e^2$.

The denominator was $r^2 (m - ak)^2$, and the fraction now becomes $\frac{m^2 a^2}{(m - ak)^2} (\frac{k^2}{mr} - \frac{k^2}{m^2 a} + \frac{k^3}{m^3}) \frac{1}{2} e^2$, which is evidently $= \varphi^2 (\frac{k^2}{mr} - \frac{k^2}{m^2 a} + \frac{k^3}{m^3}) \frac{e^2}{2}$. Now recollect that

$$k = \frac{1}{a} - \frac{1}{r}. \text{ Therefore } \frac{k^3}{m^2} = \frac{k^2}{m^2} (\frac{1}{a} - \frac{1}{r}) = \frac{k^2}{m^2 a} - \frac{k^2}{m^2 r}.$$

Therefore, instead of $-\frac{k^2}{m^2 a}$, write $-\frac{k^2}{m^2} + \frac{k^2}{m^2 r}$, and we get

$$\text{the fraction } \varphi^2 (\frac{k^3}{m^3} - \frac{k^3}{m^2} - \frac{k^2}{m^2 r} + \frac{k^2}{mr}) \frac{e^2}{2} = \varphi^2 (\frac{k^3}{m} - \frac{m k^3}{m^3} -$$

Telescope $\frac{m k^2}{m^2 r} + \frac{m^3 k^2}{m^3 r} \frac{e^2}{2}$, which is equal to $\varphi^2 \frac{1-m}{m^3} \left(k^2 - \frac{m k^2}{r} \right) \frac{e^2}{2}$,
and finally to $-\varphi^2 \frac{m-1}{m^3} \left(k^2 - \frac{m k^2}{r} \right) \frac{e^2}{2}$.

Therefore the focal distance of refracted rays is $x = \varphi$
 $-\varphi^2 \frac{m-1}{m^3} \left(k^2 - \frac{m k^2}{r} \right) \frac{e^2}{2}$.

This consists of two parts. The first φ is the focal distance of an infinitely slender pencil of central rays, and the other $-\varphi^2 \frac{m-1}{m^3} \left(k^2 - \frac{m k^2}{r} \right) \frac{e^2}{2}$ is the aberration arising from the spherical figure of the refracting surface.

Our formula has thus at last put on a very simple form, and is vastly preferable to Dr Smith's for practice.

This aberration is evidently proportional to the square of the semi-aperture, and to the square of the distance φ : but, in order to obtain this simplicity, several quantities were neglected. The assumption of the equality of AX to $\frac{e^2}{2a}$ is

the first source of error. A much more accurate value of it would have been $\frac{2ae^2}{4a^2+e^2}$, for it is really $= \frac{e^2}{2a-AX}$. If

for AX we substitute its approximated value $\frac{e^2}{2a}$, we should

have $AX = \frac{e^2}{2a - \frac{e^2}{2a}} = \frac{2ae^2}{4a^2 - e^2}$. To have used this value

would not have much complicated the calculus; but it did not occur to us till we had finished the investigation, and it would have required the whole to be changed. The operation in page 346. col. 2. par. 2. is another source of error. But these errors are very inconsiderable when the aperture is moderate. They increase for the most part with an increase of aperture, but not in the proportion of any regular function of it; so that we cannot improve the formula by any manageable process, and must be contented with it. The errors are precisely the same with those of Dr Smith's theorem, and indeed with those of any that we have seen, which are not vastly more complicated.

As this is to be frequently combined with subsequent operations, we shorten the expression by putting θ for $\frac{m-1}{m^3} \left(k^2 - \frac{m k^2}{r} \right) \frac{e^2}{2}$. Then $\varphi^2 \theta$ will express the aberration of the first refraction from the focal distance of an infinitely slender pencil; and now the focal distance of refracted rays is $f = \varphi - \varphi^2 \theta$.

If the incident rays are parallel, r becomes infinite, and $\theta = \frac{m-1}{m^3} k^2 \frac{e^2}{2}$. But in this case k becomes $= \frac{1}{a}$, and $\frac{1}{\varphi} = \frac{m-1}{ma}$, and $\varphi = \frac{ma}{m-1}$, and $\varphi^2 \theta$ becomes $\frac{m^2 a^2}{(m-1)^2} \times \frac{m-1}{m^3} \times \frac{1}{a^3} \times \frac{e^2}{2} = \frac{e^2}{2(m-1)ma}$. This is the aberration of extreme parallel rays.

We must now add the refraction of another surface.

Lemma 2. If the focal distance AG be changed by a small quantity Gg, the focal distance AH will also be changed by a small quantity Hh, and we shall have

$$m \cdot AG^2 : AH^2 = Gg : Hh.$$

Draw Mg, Mb, and the perpendiculars Gi, Hk. Then, because the sines of the angles of incidence are in a constant ratio to the sines of the angles of refraction, and the increments of these small angles are proportional to the increments of the sines, these increments of the angles are in the same constant ratio. Therefore,

We have the angle CMg to HMb as m to 1 .

Now $Gg : Gi = AG : AM$,

and $Gi : Hk = m \cdot AG : HA$,

and $Hk : Hb = MA : AH$:

therefore $Gg : Hb = m \cdot AG^2 : AH^2$.

The easiest and most perspicuous method for obtaining the aberration of rays twice refracted, will be to consider the first refraction as not having any aberration, and determine the aberration of the second refraction. Then conceive the focus of the first refraction as shifted by the aberration. This will produce a change in the focal distance of the second refraction, which may be determined by this Lemma.

PROP. II. Let AM, BN (fig. 7.) be two spherical surfaces, including a refracting substance, and having their centres C and c in the line AG. Let the ray aA pass through the centres, which it will do without refraction. Let another ray mM, tending to G, be refracted by the first surface into MH, cutting the second surface in N, where it is farther refracted into NI. It is required to determine the focal distance BI?

It is plain that the sine of incidence on the second surface is to the sine of refraction into the surrounding air as 1 to m . Also BI may be determined in relation to BH,

by means of BH, Nx, Bc, and $\frac{1}{m}$, in the same way that

AH was determined in relation to AG, by means of AG, MX, AC, and m .

Let the radius of the second surface be b , and let e still express the semi-aperture, (because it hardly differs from Nx). Also let α be the thickness of the lens. Then observe, that the focal distance of the rays refracted by the first surface, (neglecting the thickness of the lens and the aberration of the first surface), is the distance of the radiant point for the second refraction, or is the focal distance of rays incident on the second surface. In place of r therefore we must take φ ;

and as we made $k = \frac{1}{a} - \frac{1}{r}$, in order to abbreviate the calculus,

let us now make $l = \frac{1}{b} - \frac{1}{\varphi}$; and make $\frac{1}{f} = \frac{1}{b} - m l$,

as we made $\frac{1}{\varphi} = \frac{1}{a} - \frac{k}{m}$. Lastly, in place of $\theta = \frac{m-1}{m^3}$

$\left(k^2 - \frac{m k^2}{r} \right) \frac{e^2}{2}$, make $\theta' = \left(\frac{1}{m} - 1 \right) m^3 \left(l^2 - \frac{l^2}{m \varphi} \right) \frac{e^2}{2} = -\frac{m-1}{m} \left(m^3 l^2 - \frac{m^2 l^2}{\varphi} \right) \frac{e^2}{2}$.

Thus we have got an expression similar to the other; and the focal distance BI, after two refractions, becomes $BI = f - f^2 \theta'$.

But this is on the supposition that BH is equal to φ , whereas it is really $\varphi - \varphi^2 \theta - \alpha$. This must occasion a change in the value just now obtained of BI. The source of the change is twofold. 1st, Because, in the value $\frac{1}{b} - \frac{1}{\varphi}$, we

must put $\frac{1}{b} - \frac{1}{\varphi - \varphi^2 \theta - \alpha}$, and because we must do the

same in the fraction $\frac{m^2 l^2}{\varphi}$. In the second place, when the

value of BH is diminished by the quantity $\varphi^2 \theta + \alpha$, BI will suffer a change in the proportion determined by the 2d Lemma. The first difference may safely be neglected, because

the value of θ is very small, by reason of the coefficient $\frac{e^2}{2}$ being

very small, and also because the variation bears a very small ratio to the quantity itself, when the true value of φ

X x 2

differs

Telescope. differs but little from that of the quantity for which it is employed. The chief change in BI is that which is determined by the Lemma. Therefore take from BI the variation of BH, multiplied by $\frac{mBI^2}{BH^2}$, which is very nearly $= \frac{mf^2}{\phi^2}$. The product of this multiplication is $mf^2\theta + \frac{mf^2\alpha}{\phi^2}$. This being taken from f , leaves us for the value of BI $f - \frac{f^2m\alpha}{\phi^2} - f^2(m\theta + \theta')$.

In this value f is the focal distance of an infinitely slender pencil of rays twice refracted by a lens having no thickness, $\alpha \frac{mf^2}{\phi^2}$ is the shortening occasioned by the thickness, and $f^2(m\theta + \theta')$ is the effect of the two aberrations arising from the aperture.

It will be convenient, for several collateral purposes, to exterminate from these formulæ the quantities k , l , and ϕ .

For this purpose make $\frac{1}{n} = \frac{1}{a} - \frac{1}{b}$. We have already $k = \frac{1}{a} - \frac{1}{r}$; and $\frac{1}{\phi} = \frac{1}{a} - \frac{1}{ma} + \frac{1}{mr}$; and $l = \frac{1}{b} - \frac{1}{\phi} = \frac{1}{b} - \frac{1}{a} + \frac{1}{ma} - \frac{1}{mr}$. Now for $\frac{1}{b} - \frac{1}{a}$ write $-\frac{1}{n}$, and we get $l = \frac{1}{ma} - \frac{1}{mr} - \frac{1}{n}$. Therefore $\frac{1}{f} = \frac{1}{b} - m l$ (by construction, page 347. Prop. II.) becomes $= \frac{1}{b} - \frac{1}{a} + \frac{1}{r} + \frac{m}{n} = \frac{m}{n} + \frac{1}{r} - \frac{1}{n} = \frac{m-1}{n} + \frac{1}{r}$.

This last value of $\frac{1}{f}$ (the reciprocal of the focus of a slender pencil twice refracted), viz. $\frac{m-1}{n} + \frac{1}{r}$, is the simplest that can be imagined, and makes n as a substitute for $\frac{1}{a} - \frac{1}{b}$; a most useful symbol, as we shall frequently find in the sequel. It also gives a very simple expression of the focal distance of parallel rays, which we may call the principal focal distance of the lens, and distinguish it in future by the symbol p ; for the expression $\frac{1}{f} = \frac{m-1}{n} + \frac{1}{r}$, becomes $\frac{1}{p} = \frac{m-1}{n}$ when the incident light is parallel. And this gives us another very simple and useful measure of f ; for $\frac{1}{f}$ becomes $= \frac{1}{p} + \frac{1}{r}$. These equations $\frac{1}{f} = \frac{m-1}{n} + \frac{1}{r}$, $\frac{1}{p} = \frac{m-1}{n}$, and $\frac{1}{f} = \frac{1}{p} + \frac{1}{r}$, deserve therefore to be made very familiar to the mind.

We may also take notice of another property of n . It is half the radius of an isosceles lens, which is equivalent to the lens whose radii are a and b : for suppose the lens to be isosceles, that is, $a = b$; then $n = \frac{1}{a} - \frac{1}{a}$. Now the second a is negative if the first be positive, or positive if the first be negative. Therefore $\frac{1}{a} - \frac{1}{b} = \frac{1+b}{a^2} = \frac{a+a}{a^2} = \frac{2}{a}$, and $\frac{1}{n} = \frac{2}{a}$, and $n = \frac{a}{2}$. Now the focal distance of this lens is $\frac{m-1}{n}$, and so is that of the other, and they are equivalent.

But, to proceed with our investigation, recollect that we had $\theta = \frac{m-1}{m^3} \left(k^3 - \frac{mk^2}{r} \right) \frac{e^2}{2}$. Therefore $m\theta = \frac{m-1}{m} \left(\frac{k^3}{m} - \frac{k^2}{r} \right) \frac{e^2}{2}$. And θ' was $= \frac{m-1}{m} \left(-m^3 l^3 + \frac{ml^2}{\phi} \right) \frac{e^2}{2}$. Therefore $m\theta + \theta'$, the aberration (neglecting the thickness of the lens) is $f^2 \frac{m-1}{m} \left(\frac{k^3}{m} - \frac{k^2}{r} - m^3 l^3 + \frac{ml^2}{\phi} \right) \frac{e^2}{2}$.

If we now write for k , l , and ϕ , their values as determined above, performing all the necessary multiplications, and arrange the terms in such a manner as to collect in one sum the coefficients of a , n , and r , we shall find 4 terms for the value of $m\theta$, and 10 for the value of θ' . The 4 are destroyed by as many with contrary signs in the value of θ' , and there remain 6 terms to express the value of $m\theta + \theta'$, which we shall express by one symbol q ; and the equation stands thus:

$$q = \frac{m-1}{m} \left(\frac{m^3}{n^3} - \frac{2m^2+m}{an^2} + \frac{m+2}{a^2n} + \frac{3m^2+m}{rn^2} - \frac{4m+4}{arn} + \frac{3m+2}{r^2n} \right) \frac{e^2}{2}.$$

The focal distance therefore of rays twice refracted, reckoned from the last surface, or BI, corrected for aberration, and for the thickness of the lens, is $f - f \frac{2m\alpha}{\phi^2} - f^2 q$, consisting of three parts, viz. f , the focal distance of central rays; $f^2 \frac{m\alpha}{\phi^2}$, the correction for the thickness of the lens; and $f^2 q$, the aberration.

The formula in the 2d par. of this col. appears very complex, but is of very easy management, requiring only the preparation of the simple numbers which form the numerators of the fractions included in the parenthesis. When the incident rays are parallel, the terms vanish which have r in the denominator, so that only the three first terms are used.

We might here point out the cases which reduce the aberration expressed in the formula last referred to, to nothing; but as they can scarcely occur in the object-glass of a telescope, we omit it for the present, and proceed to the combination of two or more lenses.

Lemma 3. If AG be changed by a small quantity Gg, BI suffers a change Ii, and $Gg : Ii = AG^2 : BI^2$. For it is well known that the small angles GMg and INi are equal; and therefore their subtenses Gk, In are proportional to MG, NI, or to AG, AI nearly, when the aperture is moderate. Therefore we have (nearly)

$$Gk : In : AG : BI$$

$$In : Ii = AM : BI$$

$$Gg : Gk = AG : AM$$

$$\text{Therefore } Gg : Ii = AG^2 : BI^2$$

PROP. III. To determine the focal distance of rays refracted by two lenses placed near to each other on a common axis.

Let AM, BN (fig. 8.) be the surfaces of the first lens, and CO, DP be the surfaces of the second, and let β be the thickness of the second lens, and δ the interval between them. Let the radius of the anterior surface of the second lens be a' , and the radius of its posterior surface be b' . Let m' be to 1 as the sine of incidence to the sine of refraction in the substance of the second lens. Lastly, let p' be the principal focal distance of the second lens. Let the extreme or marginal ray meet the axis in L after passing thro' both lenses, so that DL is the ultimate focal distance, reckoned from the last surface.

It is plain that DL may be determined by means of a' , b' , m' , p' , and CI, in the same manner that BI was determined by means of a , b , m , p , and AG.

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The value of BI is $f - m \alpha \frac{f^2}{\phi^2} - f^2 q$. Take from this the interval δ , and we have $CI = f - m \alpha \frac{f^2}{\phi^2} - \delta - f^2 q$.

Let the small part $-m \alpha \frac{f^2}{\phi^2} - \delta - f^2 q$ be neglected for the present, and let CI be supposed $= f$. As we formed ϕ , f , and q , by means of a , b , m , n , and r , let us now form ϕ' , f' , and q' , for the second lens, by means of a' , b' , m' , n' , $(= \frac{1}{a'} - \frac{1}{b'})$, and r' . ϕ' will be the focal distance of a slender pencil refracted by the first surface, f' will be the focal distance of this pencil after two refractions, and q' will be the coefficient of the aberration, neglecting the thickness and interval of the lenses.

Proceeding in this way, DL will be $= f' - m \beta \frac{f'^2}{\phi'^2} - f'^2 q'$. But because CI is really less than f , by the quantity $m \alpha \frac{f^2}{\phi^2} + \delta + f^2 q$, we must (by Lemma 3.) subtract the product of this quantity, multiplied by $\frac{DL}{BI^2}$, (which is nearly $\frac{f'^2}{f^2}$), from $f' - m \beta \frac{f'^2}{\phi'^2} - f'^2 q'$.

By this process we shall have

$$DL = f' - f'^2 \left(\frac{m \alpha}{\phi^2} + \frac{\delta}{f^2} + \frac{m' \beta}{\phi'^2} \right) - f'^2 (q + q').$$

The first term f' of this value of DI is the focal distance of a slender pencil of central rays refracted by both lenses, neglecting their thickness and distance; the second term, $-f'^2 \left(\frac{m \alpha}{\phi^2} + \frac{\delta}{f^2} + \frac{m' \beta}{\phi'^2} \right)$ is the correction necessary for these circumstances; and the third term, $-f'^2 (q + q')$, is the correction for the aperture $2e$. And it is evident that q' is a formula precisely similar to q , containing the same number of terms, and differing only by the m' , a' , n' , and r' , employed in place of m , a , n , and r .

It is also evident, that if there be a third lens, we shall obtain its focal distance by a process precisely similar to that by which we obtained DL; and so on for any number of lenses.

Thus have we obtained formulæ by which the foci of rays are determined in the most general terms; and in such a manner as shall point out the connection of the curvatures, thicknesses, and distances of the lenses, with their spherical aberrations, and with the final aberration of the compound lens, and give the aberrations in separate symbols, so that we can treat them by themselves, and subject them to any conditions which may enable us to correct one of them by another.

We also see in general, that the correction for the thickness and distance of the lenses are exhibited in terms which involve only the focal distances of central rays, and have very little influence on the aberrations, and still less on the ratio of the aberrations of the different lenses. This is a most convenient circumstance; for we may neglect them while we are determining q and q' , and in determining the ratio of the focal distances of the several lenses, on which the correction of the chromatic aberration chiefly depends. Therefore, in the construction of a compound lens for uniting the different colours, we may neglect this correction for the thickness and distance till the end of the process. When we apply it, we shall find that it chiefly affects the final focal distance, making it somewhat longer, but has hardly any influence either on the chromatic or spherical aberration. We do not hesitate to say, that the final formulæ here given are abundantly accurate, while they are

vastly more manageable than those employed by Euler or D'Alembert. We have calculated trigonometrically the progress of the rays through one of the glasses, which will be given as an example, giving it a very extravagant aperture, that the errors of the formulæ might be very remarkable. We found the real aberration exceed the aberration assigned by the formula by no more than $\frac{1}{37}$ th part, a difference which is quite insignificant. The process here given derives its simplicity from the frequent occurrence of harmonic proportions in all optical theorems. This enabled Mr Clairaut to employ the reciprocals of the radii and distances with so much simplicity and generality.

We consider it as another advantage of Mr Clairaut's method, that it gives, by the way, formulæ for the more ordinary questions in optics, which are of wonderful simplicity, and most easily remembered. The chief problems in the elementary construction of optical instruments relate to the focal distances of central rays. This determines the focal distances and arrangement of the glasses. All the rest may be called the refinement of optics; teaching us how to avoid or correct the indistinctness, the colours, and the distortions, which are produced in the images formed by these simple constructions. We shall mention a few of these formulæ which occur in our process, and tend greatly to abbreviate it when managed by an experienced analyst.

Let m be to 1 as the sine of incidence to the sine of refraction; let a and b be the radii of the anterior and posterior surfaces of a lens; let r be the distance of the radiant point, or the focus of incident central rays, and f the distance of the conjugate focus; and let ϕ be the principal focal distance of the lens, or the focal distance of parallel rays.

Make $\frac{1}{n}$ equal to $\frac{1}{a} - \frac{1}{b}$; let the same letters a' , b' , r' , &c. express the same things for a second lens; and a'' , b'' , r'' , &c. express them for a third; and so on. Then we have $\frac{1}{f} = \frac{m-1}{n} + \frac{1}{r}$; $\frac{1}{f'} = \frac{m'-1}{n'} + \frac{1}{r'}$; $\frac{1}{f''} = \frac{m''-1}{n''} + \frac{1}{r''}$, &c.

Therefore when the incident light is parallel, and r infinite, we have $\frac{1}{\phi} = \frac{m-1}{n}$; $\frac{1}{\phi'} = \frac{m'-1}{n'}$; $\frac{1}{\phi''} = \frac{m''-1}{n''}$, &c.

And when several lenses are contiguous, so that their intervals may be neglected, and therefore $\frac{1}{f}$, belonging to the first lens, becomes $\frac{1}{r}$, belonging to the second, we have

$$1. \frac{1}{r'} = \frac{1}{f}, = \frac{m-1}{n} + \frac{1}{r}, = \frac{1}{\phi} + \frac{1}{r}.$$

$$2. \frac{1}{r''} = \frac{1}{f'}, = \frac{m'-1}{n'} + \frac{m-1}{n} + \frac{1}{r}, = \frac{1}{\phi'} + \frac{1}{\phi} + \frac{1}{r}.$$

$$3. \frac{1}{f''} = \frac{m''-1}{n''} + \frac{m'-1}{n'} + \frac{m-1}{n} + \frac{1}{r}, = \frac{1}{\phi''} + \frac{1}{\phi'} + \frac{1}{\phi} + \frac{1}{r}.$$

Nothing can be more easily remembered than these formulæ, how numerous so ever the glasses may be.

Having thus obtained the necessary analysis and formula, it now remains to apply them to the construction of achromatic lenses; in which it fortunately happens, that the employment of several surfaces, in order to produce the union of the differently refrangible rays, enables us at the same time to employ them for correcting each other's spherical aberration.

In the article OPTICS we gave a general notion of the principle on which we may proceed in our endeavours to unite the differently refrangible rays. A white or compounded ray is separated by refraction into its component coloured rays, and they are diffused over a small angular space. Thus it appears, that the glass used by Sir Isaac Newton

Telescope. Newton in his experiments diffused a white ray, which was incident on its posterior surface in an angle of 30° , in such a manner that the extreme red ray emerged into air, making an angle of $50^\circ 21\frac{1}{2}'$ with the perpendicular; the extreme violet ray emerged in an angle of $51^\circ 15\frac{1}{2}'$; and the ray which was in the confines of green and blue, emerged in an angle of $50^\circ 48\frac{1}{2}'$. If the sine of the angle 30° of incidence be called 0,5, which it really is, the sine of the emergence of the red ray will be 0,77; that of the violet ray will be 0,78; and that of the intermediate ray will be $0,77\frac{1}{2}$, an exact mean between the two extremes. This ray may therefore be called the mean refrangible ray, and the ratio of $77\frac{1}{2}$ to 50, or of 1,55 to 1, will very properly express the mean refraction of this glass; and we have for this glass $m = 1,55$. The sine of refraction, being measured on a scale, of which the sine of incidence occupies 100 parts, will be 154 for the red ray, 155 for the mean ray, and 156 for the violet ray. This number, or its ratio to unity, is commonly taken to represent the refractive power of the glass. There is some impropriety in this, unless we consider ratios as measured by their logarithms: for if m be 1, the substance does not refract at all. The refractive power can be properly measured only by the refraction which it produces; that is, by the change which it makes in the direction of the light, or the angle contained between the incident and refracted rays. If two substances produce such deviations always in one proportion, we should then say that their refractive powers are in that proportion. This is not true in any substances; but the sines of the angles, contained between the refracted ray and the perpendicular, are always in one proportion when the angle of incidence in both substances is the same. This being a cognizable function of the real refraction, has therefore been assumed as the only convenient measure of the refractive powers. Although it is not strictly just, it answers extremely well in the most usual cases in optical instruments: the refractions are moderate; and the sines are very nearly as the angles contained between the rays and the perpendicular; and the real angles of refraction, or deflections of the rays, are almost exactly proportional to $m-1$. The most natural and obvious measure of the refractive powers would therefore be $m-1$. But this would embarrass some very frequent calculations; and we therefore find it best, on the whole, to take m itself for the measure of the refractive power.

The separation of the red, violet, and intervening rays, has been called *dispersion*; and although this arises merely from a difference of the refractive power in respect of the different rays, it is convenient to distinguish this particular modification of the refractive power by a name, and we call it the **DISPERSIVE POWER** of the refracting substance.

It is susceptible of degrees; for a piece of flint-glass will refract the light, so that when the sine of refraction of the red ray is 77, the sine of the refraction of the violet ray is nearly $78\frac{1}{2}$; or if the sine of refraction of the red ray, measured on a particular scale, is 1,54, the sine of refraction of the violet ray is 1,57. The dispersion of this substance, being measured by the difference of the extreme sines of refraction, is greater than the dispersion of the other glass, in the proportion of 3 to 2.

But this alone is not a sufficient measure of the absolute dispersive power of a substance. Although the ratio of 1,54 to 1,56 remains constant, whatever the real magnitude of the refractions of common glass may be, and though we therefore say that its dispersive power is constant, we know, that by increasing the incidence and the refraction, the absolute dispersion is also increased. Another substance shows the same properties, and in a particular case may produce

the same dispersion; yet it has not for this sole reason the same dispersive power. If indeed the incidence and the refraction of the mean ray be also the same, the dispersive power cannot be said to differ; but if the incidence and the refraction of the mean ray be less, the dispersive power must be considered as greater, though the actual dispersion be the same; because if we increase the incidence till it becomes equal to that in the common glass, the dispersion will now be increased. The proper way of conceiving the dispersion therefore is, to consider it as a portion of the whole refraction; and if we find a substance making the same dispersion with half the general refraction, we must say that the dispersive quality is double; because by making the refraction equal, the dispersion will really be double.

If therefore we take m as a symbol of the separation of the extreme rays from the middle ray, $\frac{m}{m-1}$ is the natural measure of the dispersive power. We shall express this in the Leibnitzian notation, thus $\frac{dm}{m-1}$, that we may avoid the indistinctness which the Newtonian notation would occasion when m is changed for m' or m'' .

It is not unusual for optical writers to take the whole separation of the red and violet rays for the measure of the dispersive power, and to compare this with the refracting power with respect to one of the extreme rays. But it is surely better to consider the mean refraction as the measure of the refracting power: and the deviation of either of the extremes from this mean is a proper enough measure of the dispersion, being always half of it. It is attended with this convenience, that being introduced into our computations as a quantity infinitely small, and treated as such for the ease of computation, while it is really a quantity of sensible magnitude; the errors arising from this supposition are diminished greatly, by taking one half of the deviation and comparing it with the mean refraction. This method has, however, this inconvenience, that it does not exhibit at once the refractive power in all substances respecting any particular colour of light; for it is not the ray of any particular colour that suffers the mean refraction. In common glass it is the ray which is in the confines of the yellow and blue; in flint glass it is nearly the middle blue ray; and in other substances it is a different ray. These circumstances appear plainly in the different proportions of the colours of the prismatic spectrum exhibited by different substances. This will be considered afterwards, being a great bar to the perfection of achromatic instruments.

The way in which an achromatic lens is constructed is, to make use of a contrary refraction of a second lens to destroy the dispersion or spherical aberration of the first.

The first purpose will be answered if $\frac{dm}{n}$ be equal to to $-\frac{dm'}{n'}$. For, in order that the different coloured rays may be collected into one point by two lenses, it is only necessary that $\frac{1}{f}$, the reciprocal of the focal distance of rays refracted by both, may be the same for the extreme and mean rays, that is, that $\frac{m+dm}{n} - \frac{1}{n} + \frac{m'+dm'}{n'} - \frac{1}{n'} + \frac{1}{r}$ be of the same value with $\frac{m-1}{n} + \frac{m'-1}{n'} + \frac{1}{r}$; which must happen if $\frac{dm}{n} + \frac{dm'}{n'}$ be $= 0$, or $\frac{dm}{n} = -\frac{dm'}{n'}$. This may be seen in another way, more comprehensible by such as are not versant in these discussions. In order

Telescope. der that the extreme colours which are separated by the first lens may be rendered parallel by the second; we have shown already that n and n' are proportional to the radii of the equivalent isosceles lenses, being the halves of these radii. They are therefore (in these small refractions) inversely proportional to the angles formed by the surfaces at the edges of the lenses. n' may therefore be taken for the angle of the first lens, and n for that of the second. Now the small refraction by a prism, whose angle (also small) is n' , is $m - 1 \times n'$. The dispersive power being now substituted for the refractive power, we have for this refraction of the prism $dm \times n'$. This must be destroyed by the opposite refraction of the other prism $dm' \times n$. Therefore $dm \times n' = dm' \times n$, or $\frac{dm}{n} = -\frac{dm'}{n'}$. In like manner, this effect will be produced by three lenses if $\frac{dm}{n} + \frac{dm'}{n'} + \frac{dm''}{n''} = 0$, &c.

Lastly, the errors arising from the spherical figure, which we expressed by $-R^2 (q + q')$ will be corrected if $q + q' = 0$. We are therefore to discover the adjustments of the quantities employed in the preceding formulæ, which will insure these conditions. It will render the process more perspicuous if we collect into one view the significations of our various symbols, and the principal equations which we are to employ.

1. The ratios to unity of the sines of mean incidence in the different media are m, m', m''

2. The ratio of the differences of the sines of the extremes $\frac{dm}{dm'} = u$

3. The ratio $\frac{m-1}{m'-1} = c$

4. The radii of the surfaces $a, b; a', b'; a'', b''$

5. The principal focal distances, or the focal distances of parallel central rays, p, p', p''

6. The focal distance of the compound lens P

7. The distance of the radiant point, or of the focus of incident rays on each lens r, r', r''

8. The focal distance of the rays refracted by each lens f, f', f''

9. The focal distance of rays refracted by the compound lens F

10. The half breadth of the lens e

Also the following subsidiary values:

$$1. \frac{1}{n} = \frac{1}{a} - \frac{1}{b}; \frac{1}{n'} = \frac{1}{a'} - \frac{1}{b'}; \frac{1}{n''} = \frac{1}{a''} - \frac{1}{b''}$$

$$2. q = \frac{m-1}{m} \left(\frac{m^3}{n^3} - \frac{2m^2+m}{an^2} + \frac{m+2}{a^2n} + \frac{3m^2+m}{rn^2} - \frac{4(m+1)}{arn} + \frac{3m+2}{r^2n} \right) \frac{e^2}{2}. \text{ And } q' \text{ and } q'' \text{ must be formed in the same manner from } m', a', n', r'; \text{ and from } m'', a'', n'', r'', \text{ as } q \text{ is formed from } m, a, n, r.$$

3. Also, because in the case of an object-glass, r is infinitely great, the last term $\frac{1}{r}$ in all the values of $\frac{1}{f}, \frac{1}{f'}, \frac{1}{f''}$, $\frac{1}{x}, \frac{1}{x'}$, will vanish, and we shall also have $F = P$.

$$\text{Therefore in a double object-glass } \frac{1}{P} = \frac{m'-1}{n'} + \frac{m-1}{n}, \\ = \frac{1}{p'} + \frac{1}{p}.$$

$$\text{And in a triple object-glass } \frac{1}{P} = \frac{m''-1}{n''} + \frac{m'-1}{n'} + \frac{m-1}{n}, \\ = \frac{1}{p''} + \frac{1}{p'} + \frac{1}{p}.$$

Also, in a double object-glass, the correction of spherical aberration requires $q + q' = 0$.

And a triple object-glass requires $q + q' + q'' = 0$. For the whole error is multiplied by F^2 , and by $\frac{1}{2}e^2$; and therefore the equation which corrects this error may be divided by $F^2 \frac{1}{2}e^2$.

This equation in the preceding column, 11th line from the bottom, giving the value of q, q', q'' , may be much simplified as follows: In the first place, they may be divided by m, m' , or m'' , by applying them properly to the terms within the parenthesis, and expunging them from the denominator of the general factors $\frac{m-1}{m}, \frac{m'-1}{m'}, \frac{m''-1}{m''}$. This does not alter the values of q, q' , and q'' . In the second place the whole equations may be afterwards divided by $m'-1$. This will give the values of $\frac{q}{m'-1}, \frac{q'}{m'-1}$, and $\frac{q''}{m'-1}$, which will still be equal to nothing if $q + q' + q''$ be equal to nothing.

This division reduces the general factor $\frac{m'-1}{m'}$ of q' to $\frac{1}{m'}$. And in the equation for q we obtain, in place of the

general factor $\frac{m-1}{m}$, the factor $\frac{m-1}{m'-1}$, or c . This will also be the factor of the value of q'' when the third lens is of the same substance with the first, as is generally the case. And, in the third place, since the rays incident on the first lens are parallel, all the terms vanish from the value of q in which $\frac{1}{r}$ is found, and there remain only the three first,

$$\text{viz. } \frac{m^3}{n^3} - \frac{2m^2+m}{an^2} + \frac{m+2}{a^2n}.$$

Performing these operations, we have

$$\frac{q}{m'-1} = c \left(\frac{m^2}{n^3} - \frac{2m+1}{an^2} + \frac{m+2}{a^2n} \right) \frac{e^2}{2} \\ \frac{q'}{m'-1} = \left(\frac{m'^2}{n'^3} - \frac{2m'+1}{a'n'^2} + \frac{m'+2}{a'^2n'} + \frac{3m'+1}{r'n'^2} - \frac{4(m'+1)}{m'a'r'n'} + \frac{3m'+2}{m'r'^2n'} \right) \frac{e^2}{2} \\ \frac{q''}{m'-1} = c \left(\frac{m^2}{n'^3} - \frac{2m+1}{a'n'^2} + \frac{m+2}{m'a'^2n''} + \frac{3m+1}{r'n'^2} + \frac{4(m+1)}{m'a'r'n''} + \frac{3m+2}{m'r'^2n''} \right) \frac{e^2}{2}$$

Let us now apply this investigation to the construction of an object-glass; and we shall begin with a double lens.

Construction of a Double Achromatic Object-glass.

Here we have to determine four radii a, b, a' , and b' . Make $n=1$. This greatly simplifies the calculus, by exterminating it from all the denominators. This gives for the

$$\text{equation } \frac{dm}{n} + \frac{dm'}{n'} = 0, \text{ the equation } dm + \frac{dm'}{n'} = 0, \text{ or } dm = -\frac{dm'}{n'}, \text{ and } \frac{1}{n'} = -\frac{dm}{dm'}, = -u.$$

Also we have r' , the focal distance of the light incident on the second lens, the same with the principal focal distance p of the first lens (neglecting the interval, if any). Now $\frac{1}{p} = \frac{m-1}{n}$, which in the present case is $= m-1$. Also $\frac{1}{p'}$ is $= -u(m'-1)$, and $\frac{1}{P} = m-1-u(m'-1) = u'$.

Make these substitutions in the values of $\frac{q}{m-1}$ and $\frac{q'}{m'-1}$, and we obtain the following equation:

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$$cm^2 - \frac{c(2m+1)}{a} + \frac{c(m+2)}{ma^2} - u^3 m'^2 - \frac{u^2(2m'+1)}{a'} - \frac{u(m'+2)}{m'a'^2} + u^2(3m'+1)(m-1) + \frac{4u(m'+1)(m-1)}{m'a'} - \frac{u(3m'+2)(m-1)^2}{m'} = 0.$$

Arrange these terms in order, according as they are factors of $\frac{1}{a^2}$, $\frac{1}{a}$, $\frac{1}{a'^2}$, $\frac{1}{a'}$, or independent quantities. It puts on this form:

$$\frac{c(m+2)}{m} \times \frac{1}{a^2} - c'(2m+1) \times \frac{1}{a} - \frac{u(m'+2)}{m'} \times \frac{1}{a'^2} - \left(u^2(2m'+1) - \frac{4u(m'+1)(m-1)}{m'} \right) \times \frac{1}{a'} + cm^2 + u^2(3m'+1)(m-1) - u^3 m'^2 - \frac{u(3m'+2)(m-1)^2}{m'} = 0.$$

Let A be the coefficient of $\frac{1}{a^2}$, B that of $\frac{1}{a}$, C that of $\frac{1}{a'^2}$, D that of $\frac{1}{a'}$, and E the sum of the independent quantity; that is, let A be $= \frac{c(m+2)}{m}$, B $= c(2m+1)$, C $= \frac{u(m'+2)}{m'}$, D $= u^2(2m'+1) - \frac{4u(m'+1)(m-1)}{m'}$, and E $= cm^2 + u^2(3m'+1)(m-1) - u^3 m'^2 - \frac{u(3m'+2)(m-1)^2}{m'}$.

Our final equation becomes

$$\frac{A}{a^2} - \frac{B}{a} - \frac{C}{a'^2} - \frac{D}{a'} + E = 0.$$

The coefficients of this equation and the independent quantity are all known, from our knowledge of m , m' , dm , dm' ; and we are to find the values of a and a' , and from them and $n=1$ to find the values of b and b' .

But it is evidently an indeterminate equation, because there are two unknown quantities; so that there may be an infinity of solutions. It must be rendered determinate by means of some other conditions to which it may be subjected. These conditions must depend on some other circumstances which may direct our choice.

One circumstance occurs to us which we think of very great consequence. In the passage of light from one substance to another, there is always a considerable portion reflected from the posterior surface of the first and from the anterior surface of the last; and this reflection is more copious in proportion to the refraction. This loss of light will therefore be diminished by making the internal surfaces of the lenses to coincide; that is, by making $b=a'$. This will be attended with another advantage. If we put between the glasses a substance of nearly the same refracting power, we shall not only completely prevent this loss of light, but we shall greatly diminish the errors which arise from an imperfect polish of the surfaces. We have tried this, and find the effect very surprising. The lens being polished immediately after the figure has been given it, and while it was almost impervious to light by reason of its roughness, which was still sensible to the naked eye, performed as well as when finished in the finest manner.

N. B. This condition, by taking away one refraction, obliges us to increase those which remain, and therefore increases the spherical aberrations. And since our formulæ do not fully remove those (by reason of the small quantities neglected in the process), it is uncertain whether this condition be the most eligible. We have, however, no direct argument to the contrary.

Let us see what determination this gives us.

In this case $\frac{1}{a'} = \frac{1}{b}$, $= \frac{1}{a} - 1$. For because $\frac{1}{n} = \frac{1}{a} - \frac{1}{b}$. Telescope.

and $n=1$, we have $1 + \frac{1}{b} = \frac{1}{a}$, and $\frac{1}{b} = \frac{1}{a} - 1$. Therefore $\frac{1}{a'^2} = \frac{1}{a^2} - \frac{2}{a} + 1$. Therefore, in our final equation,

put $\frac{1}{a^2} - \frac{2}{a} + 1$ in place of $\frac{1}{a'^2}$, and $\frac{1}{a} - 1$ in place of $\frac{1}{a'}$, and it becomes $\frac{A-C}{a^2} - \frac{B+D-2C}{a} + E + D - C = 0$.

Thus have we arrived at a common affected quadratic equation, where $\frac{1}{a}$ is the unknown quantity. It has the common form $p x^2 + q x + r = 0$, where p is $= A-C$, q is equal to $2C-B-D$, r is equal to $E+D-C$, and x is equal to $\frac{1}{a}$.

Divide the equation by p , and we have $x^2 + \frac{q}{p} x + \frac{r}{p} = 0$. Make $s = \frac{q}{p}$ and $t = \frac{r}{p}$, and we have $x^2 + s x + t = 0$.

This gives us finally $\frac{1}{a}$, or $x = -\frac{1}{2}s \pm \sqrt{\frac{1}{4}s^2 - t}$.

This value of $\frac{1}{a}$ is taken from a scale of which the unit is half the radius of the isosceles lens which is equivalent to the first lens, or has the same focal distance with it. We must then find (on the same scale) the value of b , viz. $\frac{1}{a} - 1$, which is also the value of a' . Having obtained a' , we must find b' by means of the equation $\frac{1}{n} = \frac{1}{a} - \frac{1}{b'}$ and therefore $\frac{1}{b'} = \frac{1}{a} - \frac{1}{n}$. But $\frac{1}{n} = u$. Therefore $\frac{1}{b'} = \frac{1}{a} + u = \frac{1}{a} + u - 1$.

Thus is our object-glass constructed; and we must determine its focal distance, or its reciprocal $\frac{1}{P}$. This is $= m-1 - u(m'-1)$.

All these radii and distances are measured on a scale of which n is the unit. But it is more convenient to measure every thing by the focal distance of the compound object-glass. This gives us the proportion which all the distances bear to it. Therefore, calling P unity, in order to obtain $\frac{1}{a}$ on this scale, we have only to state the analogy $m-1-u(m'-1) : 1 :: \frac{1}{a} : A$, and A is the radius of our first surface measured on a scale of which P is the unit.

If, in the formula which expresses the final equation for $\frac{1}{a}$, the value of t should be positive, and greater than $\frac{1}{4}s^2$, the equation has imaginary roots; and it is not possible with the glasses employed, and the conditions assumed, to correct both the chromatic and spherical aberrations.

If t is negative and equal to $\frac{1}{4}s^2$, the radical part of the value is $= 0$, and $\frac{1}{a} = -\frac{1}{2}s$. But if it be negative or positive, but less than $\frac{1}{4}s^2$, the equation has two real roots, which will give two constructions. That is to be preferred which gives the smallest curvature of the surfaces; because, since in our formulæ which determine the spherical aberration some quantities are neglected, these quantities are always

Telescope. ways greater when a large arch (that is, an arch of many degrees) is employed. No radius should be admitted which is much less than $\frac{1}{4}$ of the focal distance.

All this process will be made plain and easy by an example.

Very careful experiments have shown, that in common crown-glass the sine of incidence is to the sine of refraction as 1,526 is to 1, and that in the generality of flint-glass it is as 1,604 to 1. Also that $\frac{dm}{dm'} = 0,6054 = u$. There-

fore $m - 1 = 0,526$; $m' - 1 = 0,604$; $c = \frac{m - 1}{m' - 1} = 0,87086$. By these numbers we can compute the coefficients of our final equation. We shall find them as follows:

$$\begin{aligned} A &= 2,012 \\ B &= 3,529 \\ C &= 1,360 \\ D &= -0,526 \\ E &= 1,8659 \end{aligned}$$

The general equation (p. 352. l. 17.), when subjected to the assumed coincidence of the internal surfaces, is $\frac{A - C}{a^2} -$

$\frac{B + D - 2C}{a} + E + D - C = 0$. $A - C$ is $= 0,652$; $B + D - 2C$ is $= 0,283$; and $E + D - C$ is $= -0,020$; and the equation with numerical coefficients is $\frac{0,652}{a^2} -$

$\frac{0,283}{a} - 0,020 = 0$, which corresponds to the equation

$px^2 + qx + r = 0$. We must now make $s = \frac{q}{p} =$

$\frac{0,283}{0,652} = 0,434$, and $t = \frac{r}{p} = \frac{0,02}{0,652} = 0,0307$. This

gives us the final quadratic equation $\frac{1}{a^2} - \frac{0,434}{a} - 0,0307$

$= 0$. To solve this, we have $-\frac{1}{2}s = 0,217$, and $\frac{1}{4}s^2 = 0,0471$. From this take t , which is $= -0,0307$ (that is, to $0,0471$ add $0,0307$), and we obtain $0,0778$, the square

root of which is $= 0,2789$. Therefore, finally, $\frac{1}{a} =$

$0,2170 \pm 0,2789$, which is either $0,4959$ or $-0,0619$.

It is plain that the first must be preferred, because the second gives a negative radius, or makes the first surface of the crown-glass concave. Now as the convergence of the rays is to be produced by the crown-glass, the other surface must become very convex, and occasion great errors in the computed aberration. We therefore retain $0,4959$ for

the value of $\frac{1}{a}$, and a is $= \frac{1}{0,4959} = 2,0166$.

To obtain b , use the equation $\frac{1}{b} = \frac{1}{a} - 1$, which gives

$\frac{1}{b} = -0,5041$, and therefore a convex surface. b is there-

fore $= \frac{1}{0,5041} = 1,9837$.

a' is the same with b , and $\frac{1}{a'} = -0,5041$.

To obtain b' , use the equation $\frac{1}{b'} = \frac{1}{a} + u$. Now $u =$

$0,6054$, and $\frac{1}{a} = -0,5041$. The sum of these is $0,1013$;

and since it is positive, the surface is concave. $b' = \frac{1}{0,1013} = 9,872$.

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Lastly, $\frac{1}{P} = m - 1 - u(m' - 1) = 0,1603$, and $P =$ Telescope.

$\frac{1}{0,1603} = 0,2383$.

Now to obtain all the measures in terms of the focal distance P , we have only to divide the measures already found by $0,2383$, and the quotients are the measures wanted.

Therefore $a = \frac{2,0166}{0,2383} = 0,32325$

$b = \frac{1,9837}{0,2383} = -0,31798$

$a' = - - = -0,31798$

$b' = \frac{9,872}{0,2383} = 1,5825$

$P = - 1$.

If it be intended that the focal distance of the object-glass shall be any number n of inches or feet, we have only to multiply each of the above radii by n , and we have their lengths in inches or feet.

Thus we have completed the investigation of the construction of a double object-glass. Although this was intricate, the final result is abundantly simple for practice, especially with the assistance of logarithms. The only troublesome thing is the preparation of the numerical coefficients A, B, C, D, E of the final equation. Strict attention must also be paid to the positive and negative signs of the quantities employed.

We might propose other conditions. Thus it is natural to prefer for the first or crown-glass lens such a form as shall give it the smallest possible aberration. This will require a small aberration of the flint-glass to correct it. But a little reflection will convince us that this form will not be good. The focal distance of the crown-glass must not exceed one-third of that of the compound glass; these two being nearly in the proportion of $dm' - dm$ to dm' . Therefore if this form be adopted, and a be made about $\frac{1}{3}$ th of b , it will not exceed $\frac{1}{3}$ th of P . Therefore, although we may produce a most accurate union of the central and marginal rays by opposite aberrations, there will be a considerable aberration of some rays which are between the centre and the margin.

It is absolutely impossible to collect into one point the whole rays (though the very remotest rays are united with the central rays), except in a very particular case, which cannot obtain in an object-glass; and the small quantities which are neglected in the formula which we have given for the spherical aberration, produce errors which do not follow any proportion of the aperture which can be expressed by an equation of a manageable form. When the aperture is very large, it is better not to correct the aberration for the whole aperture, but for about $\frac{2}{3}$ ths of it. When the rays corresponding to this distance are made to coincide with the central rays by means of opposite aberrations, the rays which are beyond this distance will be united with some of those which are nearer to the centre, and the whole diffusion will be considerably diminished. Dr Smith has illustrated this in a very perspicuous manner in his theory of his Catoptric Microscope.

But although we cannot adopt this form of an object-glass, there may be other considerations which may lead us to prefer some particular form of the crown glass, or of the flint-glass. We shall therefore adapt our general equation $\frac{A}{a^2} -$

$\frac{B}{a} - \frac{C}{a^2} - \frac{D}{a} + E = 0$ to this condition.

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There

Telescope.

Therefore let b express this selected ratio of the two radii of the crown-glass, making $\frac{a}{b} = b$ (remembering always that a is positive and b negative in the case of a double convex, and b is a negative number).

With this condition we have $\frac{1}{b} = \frac{b}{a}$. But when we make n the unit of our formula of aberration, $\frac{1}{b} = \frac{1}{a} - 1$. Therefore $1 = \frac{1}{a} - \frac{b}{a}$, and $\frac{1}{a} = \frac{1}{1-b}$. Now substitute this for $\frac{1}{a}$ in the general equation, and change all the signs (which still preserves it = 0), and we obtain

$$\frac{C}{a'^2} + \frac{D}{a'} - E - \frac{A}{(1-b)^2} + \frac{B}{1-b} = 0.$$

By this equation we are to find $\frac{1}{a'}$, or the radius of the anterior surface of the flint-glass. The equation is of this form $px^2 + qx + r = 0$, and we must again make $s = \frac{q}{p}$, and $t = \frac{r}{p}$. Therefore $s = \frac{D}{C}$, and $t = \frac{1}{C} \times \left(\frac{B}{1-b} - \frac{A}{(1-b)^2} - E \right)$. Then, finally,

$$\frac{1}{a'} = -\frac{1}{2}s \pm \sqrt{\frac{1}{4}s^2 - t}.$$

It may be worth while to take a particular case of this condition. Suppose the crown glass to be of equal convexities on both sides. This has some advantages: We can tell with precision whether the curvatures are precisely equal, by measuring the focal distance of rays reflected back from its posterior surface. These distances will be precisely equal. Now it is of the utmost importance in the construction of an object-glass which is to correct the spherical aberration, that the forms be precisely such as are required by our formulæ.

In this case of a lens equally convex on both sides

$\frac{1}{a}$ is = $-\frac{1}{b}$, = $\frac{1}{2}$. Substitute this value for $\frac{1}{a}$ in the general equation $\frac{A}{a^2} - \frac{B}{a} - \frac{C}{a'^2} - \frac{D}{a'} + E = 0$, and then $\frac{A}{a^2} = \frac{A}{4}$; $\frac{B}{a}$ becomes $\frac{B}{2}$. Now change all the signs, and we have $\frac{C}{a'^2} + \frac{D}{a'} - E - \frac{A}{4} + \frac{B}{2} = 0$, by which we are to find a' . This in numbers is $\frac{1,360}{a'^2} - \frac{0,526}{a'} - 0,6044 = 0$. Then $s = \frac{-0,526}{1,360} = -0,3867$, and $t = \frac{-0,6044}{1,360} = -0,4444$. Then $-\frac{1}{2}s = 0,1933$; $\frac{1}{4}s^2 = 0,0374$; and $\sqrt{\frac{1}{4}s^2 - t} = \pm 0,6941$; so that $\frac{1}{a'} = 0,1933 \pm 0,6941$. This gives two real roots, viz. 0,8874, and -0,5008. If we take the first, we shall have a convex anterior surface for the flint-glass, and consequently a very deep concave for the posterior surface. We therefore take the second or negative root -0,5008.

We find $\frac{1}{b}$, as before, by the equation $\frac{1}{b} = \frac{1}{a'} + u$, = 0,1046, which will give a large value of b .

We had $\frac{1}{a} = \frac{1}{2}$

and $\frac{1}{b} = -\frac{1}{2}$

and $\frac{1}{P}$ is the same as in the former case, viz. 0,1603.

Having all these reciprocals, we may find a, b, a', b' , and P ; and then dividing them by P , we obtain finally

$$\begin{aligned} a &= 0,3206 \\ b &= -0,3206 \\ a' &= -0,3201 \\ b' &= 1,533 \\ P &= 1, \end{aligned}$$

By comparing this object-glass with the former, we may remark, that diminishing a a little increases b , and in this respect improves the lens. It indeed has diminished b' , but this being already considerable, no inconvenience attends this diminution. But we learn, at the same time, that the advantage *must* be very small; for we cannot diminish a much more, without making it as small as the smallest radius of the object-glass. This proportion is therefore very near the maximum, or best possible; and we know that in such cases, even considerable changes in the radii will make but small changes in the result: for these reasons we are disposed to give a strong preference to the first construction, on account of the other advantages which we showed to attend it.

As another example, we may take a case which is very nearly the general practice of the London artists. The radius of curvature for the anterior surface of the convex crown-glass is $\frac{5}{8}$ th of the radius of the posterior surface, so that $b = \frac{5}{8}$. This being introduced into the determinate equation, gives

$$\begin{aligned} a &= 0,2938 & a' &= -0,3443 \\ b &= -0,3526 & b' &= 1,1474 \end{aligned}$$

As another condition, we may suppose that the second or flint-glass is of a determined form.

This case is solved much in the same manner as the former. Taking b to represent the ratio of a' and b' , we have $\frac{1}{a'}$

= $\frac{1}{1-b}$. This value being substituted in the general equation $\frac{A}{a^2} - \frac{B}{a} - \frac{C}{a'^2} - \frac{D}{a'} + E = 0$, gives us $\frac{A}{a^2} - \frac{B}{a} + E - \frac{C}{(1-b)^2} - \frac{D}{1-b} = 0$. This gives for the final equation $x^2 + sx + t = 0$, $s = \frac{B}{A}$, and $t = \frac{1}{A} \times \left(E - \frac{C}{(1-b)^2} - \frac{D}{1-b} \right)$ and $\frac{1}{a} = -\frac{1}{2}s \pm \sqrt{\frac{1}{4}s^2 - t}$.

We might here take the particular case of the flint-glass being equally concave on both sides. Then, because $\frac{1}{a'} =$

$-u$, and in the case of equal concavities $\frac{2}{a'} = \frac{1}{n}$, = $-u$,

it is sufficient to put $-\frac{1}{2}u$ for $\frac{1}{a'}$. This being done, the equation becomes $\frac{A}{a^2} - \frac{B}{a} - \frac{Cu^2}{4} + \frac{Du}{2} + E = 0$. This gives $s = \frac{B}{A}$, and $t = \frac{1}{A} \times \left(\frac{4Du - 2Cu^2}{8} + E \right)$.

We

Telescope.

Telescope.

Telescope.

We imagine that these cases are sufficient for showing the management of the general equation; and the example of the numerical solution of the first case affords instances of the only niceties which occur in the process, viz. the proper employment of the positive and negative quantities.

We have oftener than once observed, that the formula is not perfectly accurate, and that in very large apertures errors will remain. It is proper therefore, when we have obtained the form of a compound object-glass, to calculate trigonometrically the progress of the light through it; and if we find a considerable aberration, either chromatic or spherical, remaining, we must make such changes in the curvatures as will correct them. We have done this for the first example; and we find, that if the focal distance of the compound object-glass be 100 inches, there remains of the spherical aberration nearly $\frac{1}{80}$ th of an inch, and the aberration of colour is over corrected above $\frac{1}{10}$ th of an inch. The first aberration has been diminished about 6 times, and the other about 30 times. Both of the remaining errors will be diminished by increasing the radius of the inner surfaces. This will diminish the aberration of the crown-glass, and will diminish the dispersion of the flint more than that of the crown. But indeed the remaining error is hardly worth our notice.

It is evident to any person conversant with optical discussions, that we shall improve the correction of the spherical aberration by diminishing the refractions. If we employ two lenses for producing the convergency of the rays to a real focus, we shall reduce the aberration to $\frac{1}{4}$ th. Therefore a better achromatic glass will be formed of three lenses, two of which are convex and of crown-glass. The refraction being thus divided between them, the aberrations are lessened. There is no occasion to employ two concave lenses of flint-glass; there is even an advantage in using one. The aberration being considerable, less of it will serve for correcting the aberration of the crown-glass, and therefore such a form may be selected as has little aberration. Some light is indeed lost by these two additional surfaces; but this is much more than compensated by the greater apertures which we can venture to give when the curvature of the surface is so much diminished. We proceed therefore to

The Construction of a Triple Achromatic Object-glass.

It is plain that there are more conditions to be assumed before we can render this a determinate problem, and that the investigation must be more intricate. At the same time, it must give us a much greater variety of constructions, in consequence of our having more conditions necessary for giving the equation this determinate form. Our limits will not allow us to give a full account of all that may be done in this method. We shall therefore content ourselves with giving one case, which will sufficiently point out the method of proceeding. We shall then give the results in some other eligible cases, as rules to artists by which they may construct such glasses.

Let the first and second glasses be of equal curvatures on both sides; the first being a double convex of crown-glass, and the second a double concave of flint-glass.

Still making n the unit of our calculus, we have in the first place $a = -b, = -a', = b'$. Therefore $\frac{1}{a'} - \frac{1}{b'} =$

$-\left(\frac{1}{a} - \frac{1}{b}\right)$, or $\frac{1}{n} = -\frac{1}{n} = -1$. Therefore the equation

$\frac{dm}{n} + \frac{dm'}{n'} + \frac{dm''}{n''} = 0$ becomes $u - 1 + \frac{u}{n''} =$

0 , or $\frac{1}{n''} = \frac{1}{u} - 1$. Let us call this value u' .

We have $\frac{1}{p} = m - 1; \frac{1}{p'} = -(m' - 1); \frac{1}{p''} = u'$ Telescope.
 $(m - 1); \frac{1}{P} = \frac{1}{p} + \frac{1}{p'} + \frac{1}{p''} = m - m' + u' (m - 1).$

And if we make $m' - m = C'$, we shall have $\frac{1}{P} = -C' + u' (m - 1)$. Also $\frac{1}{p'} = m - 1; \frac{1}{p''} = m - 1 - (m' - 1) = m - m', = -C'$.

The equality of the two curvatures of each lens gives $\frac{1}{a} = \frac{1}{2n}$. Therefore $\frac{1}{a} = -\frac{1}{b} = -\frac{1}{a'}, = \frac{1}{b'} = \frac{1}{2}$; and $\frac{1}{b''} = \frac{1}{a''} - \frac{1}{n''} = \frac{1}{a''} - u'$.

Substituting these values in the equation (p. 351. col. 2. par. 5.), we obtain the three formulæ,

$$\begin{aligned} 1. & \quad cm^2 - \frac{1}{2}c(2m+1) + \frac{c(m+2)}{4m} \\ 2. & \quad -m'^2 + \frac{1}{2}(2m'+1) - \frac{m'+2}{4m'} + \frac{(3m'+1)(m-1)}{2(m'+1)(m-1)} - \frac{(3m'+2)(m-1)^2}{m'} \\ 3. & \quad cu'3m^2 - \frac{cu'^2(2m+1)}{a'} + \frac{cu'(m+2)}{ma'^{1/2}} - cu'u'^2 \\ & \quad (3m+1) + \frac{4cc'u'(m+1)}{ma''} + \frac{cc'^2u'(3m+2)}{m} = 0. \end{aligned}$$

Now arrange these quantities according as they are coefficients of $\frac{1}{a'^{1/2}}$ and of $\frac{1}{a''}$, or independent quantities. Let

the coefficient of $\frac{1}{a'^{1/2}}$ be A , that of $\frac{1}{a''}$ be B , and the independent quantity be C , we have

$$\begin{aligned} A &= \frac{cu'(m+2)}{m}; B = cu'^2(2m+1) - \frac{4cc'u'(m+1)}{m} \\ \text{and } C &= cm^2 + \frac{c(m+2)}{4m} + \frac{1}{2}(2m'+1) + (3m'+1) \\ & \quad (m-1) + cu'3m^2 + \frac{cc'^2u'(3m+2)}{m} - \frac{1}{2}c(2m+1) \\ & \quad - m'^2 - \frac{m'+2}{4m} - \frac{2(m'+1)(m-1)}{m'} - \frac{(3m'+2)(m-1)^2}{m'} \\ & \quad - cc'u'^2(3m+1). \end{aligned}$$

Our equation now becomes $\frac{A}{a'^{1/2}} - \frac{B}{a''} + C = 0$.

This reduced to numbers, by computing the values of the coefficients, is $\frac{1,312}{a'^{1/2}} - \frac{1,207}{a''} - 0,3257 = 0$.

This, divided by 1,312, gives $s = -0,92$; and $t = -0,2482$; $-\frac{1}{2}s = 0,46$; $\frac{1}{4}s^2 = 0,2116$; and $\sqrt{\frac{1}{4}s^2 - t} = \pm 0,6781$.

And, finally, $\frac{1}{a''} = 0,46 \pm 0,6781$.

This has two roots, viz. 0,2181 and $-1,1381$. The last would give a very small radius, and is therefore rejected.

Now, proceeding with this value of $\frac{1}{a''}$ and the $\frac{1}{n''}$, we get the other radius b'' , and then, by means of u' , we get the other radius which is common to the four surfaces.

Then, by $\frac{1}{P} = \frac{1}{p''} - c'$, we get the value of P .

The radii being all on the scale of which n is the unit, they must be divided by P to obtain their value on the scale which has P for its unit. This will give us

$$\begin{aligned} a &= -b, = -a', = b', = 0,530 \\ a'' &= 1,215 \\ b' &= -0,3046 \\ P &= 1. \end{aligned}$$

This is not a very good form, because the last surface has too great curvature.

We thought it worth while to compute the curvatures for a case where the internal surfaces of the lenses coincide, in order to obtain the advantages mentioned on a former occasion. The form is as follows:

The middle lens is a double concave of flint-glass; the last lens is of crown-glass, and has equal curvatures on both sides. The following table contains the dimensions of the glasses for a variety of focal distances. The first column contains the focal distances in inches; the second contains the radii of the first surface in inches; the third contains the radii of the posterior surface of the first lens and anterior surface of the second; and the fourth column has the radii of the three remaining surfaces.

P	a	b, a'	b', a'', b''
12	9,25	6,17	12,75
24	18,33	12,25	25,5
36	27,33	18,25	38,17
48	36,42	24,33	50,92
60	45,42	30,33	63,58
72	54,5	36,42	76,33
84	63,5	42,5	89,
96	72,6	48,5	101,75
108	81,7	54,58	114,42
120	90,7	60,58	127,17

We have had an opportunity of trying glasses of this construction, and found them equal to any of the same length, although executed by an artist by no means excellent in his profession as a glass-grinder. This very circumstance gave us the opportunity of seeing the good effects of interposing a transparent substance between the glasses. We put some clear turpentine varnish between them, which completely prevented all reflection from the internal surfaces. Accordingly these telescopes were surprisingly bright; and although the roughness left by the first grinding was very perceptible by the naked eye before the glasses were put together, yet when joined in this manner it entirely disappeared, even when the glasses were viewed with a deep magnifier.

The aperture of an object-glass of this construction of 30 inches focal distance was $3\frac{1}{2}$ th inches, which is considerably more than any of Mr Dollond's that we have seen.

If we should think it of advantage to make all the three lenses isosceles, that is, equally curved on both surfaces, the general equation will give the following radii:

$$\begin{aligned} a &= +0,639 & a' &= -0,5285 & a'' &= +0,6413 \\ b &= -0,639 & b' &= +0,5285 & b'' &= -0,6413 \end{aligned}$$

This seems a good form, having large radii.

Should we choose to have the two crown-glass lenses isosceles and equal, we must make

$$\begin{aligned} a &= +0,6412 & a' &= -0,5227 & a'' &= +0,6412 \\ b &= -0,6412 & b' &= +0,5367 & b'' &= -0,6412 \end{aligned}$$

This form hardly differs from the last.

Our readers will recollect that all these forms proceed on certain measures of the refractive and dispersive powers of the substances employed, which are expressed by m , m' , $d m$, and $d m'$: and we may be assured that the formulæ are sufficiently exact, by the comparison (which we have made in one of the cases) of the result of the formula and the trigonometrical calculation of the progress of the rays. The error was but $\frac{1}{6}$ th of the whole, ten times less than another error, which unavoidably remains, and will be considered presently. These measures of refraction and dis-

perfection were carefully taken; but there is great diversity, particularly in the flint-glass. We are well informed that the manufacture of this article has considerably changed of late years, and that it is in general less refractive and less dispersive than formerly. This must evidently make a change in the forms of achromatic glasses. The proportion of the focal distance of the crown-glasses to that of the flint must be increased, and this will occasion a change in the curvatures, which shall correct the spherical aberration. We examined with great care a parcel of flint-glass which an artist of this city got lately for the purpose of making achromatic object-glasses, and also some very white crown-glass made in Leith; and we obtained the following measures:

$$\begin{aligned} m &= 1,529 & \frac{d m}{d m'} &= \frac{142}{219} = 0,64841. \\ m' &= 1,578 \end{aligned}$$

We computed some forms for triple object-glasses made of these glasses, which we shall subjoin as a specimen of the variations which this change of data will occasion.

If all the three lenses are made isosceles, we have

$$\begin{aligned} a &= +0,796 & a' &= -0,474 & a'' &= +0,502 \\ b &= -0,796 & b' &= +0,474 & b'' &= -0,502 \end{aligned}$$

Or

$$\begin{aligned} a &= 0,504 & a' &= -0,475 & a'' &= +0,793 \\ b &= -0,504 & b' &= 0,475 & b'' &= -0,793 \end{aligned}$$

If the middle lens be isosceles, the two crown-glass lenses may be made of the same form and focal distance, and placed the same way. This will give us

$$\begin{aligned} a &= +0,705 & a' &= -0,475 & a'' &= +0,705 \\ b &= -0,547 & b' &= +0,475 & b'' &= -0,547 \end{aligned}$$

N. B. This construction allows a much better form, if the measures of refraction and dispersion are the same that we used formerly. For we shall have

$$\begin{aligned} a &= +0,628 & a' &= -0,579 & a'' &= +0,628 \\ b &= -0,749 & b' &= +0,579 & b'' &= -0,749 \end{aligned}$$

And this is pretty near the practice of the London opticians.

We may here observe, upon the whole, that an amateur has little chance of succeeding in these attempts. The diversity of glasses, and the uncertainty of the workman's producing the very curvatures which he intends, is so great, that the object-glass turns out different from our expectation. The artist who makes great numbers acquires a pretty certain guess at the remaining error; and having many lenses, intended to be of one form, but unavoidably differing a little from it, he tries several of them with the other two, and finding one better than the rest, he makes use of it to complete the set.

The great difficulty in the construction is to find the exact proportion of the dispersive powers of the crown and flint glass. The crown is pretty constant; but there is hardly two pots of flint-glass which have the same dispersive power. Even if constant, it is difficult to measure it accurately; and an error in this greatly affects the instrument, because the focal distances of the lenses must be nearly as their dispersive powers. The method of examining this circumstance, which we found most accurate, was as follows:

The sun's light, or that of a brilliant lamp, passed through a small hole in a board, and fell on another board pierced also with a small hole. Behind this was placed a fine prism A (fig. 10.), which formed a spectrum ROV on a screen pierced with a small hole. Behind this was placed a prism B of the substance under examination. The ray which was refracted by it fell on the wall at D, and the distance of its illumination from that point to C, on which an unrefracted ray would have fallen, was carefully measured. This showed the refraction of that colour. Then, in order that we might be certain that we always compared the refraction of the

Telescope. the same precise colour by the different prisms placed at B, we marked the precise position of the prism A when the ray of a particular colour fell on the prism B. This was done by an index AG attached to A, and turning with it, when we caused the different colours of the spectrum formed by A to fall on B. Having examined one prism B with respect to all the colours in the spectrum formed by A, we put another B in its place. Then bringing A to all its former positions successively, by means of a graduated arch HGK, we were certain that when the index was at the same division of the arch it was the very ray which had been made to pass through the first prism B in a former experiment. We did not solicitously endeavour to find the very extreme red and violet rays; because, although we did not learn the whole dispersions of the two prisms, we learned their proportions, which is the circumstance wanted in the construction of achromatic glasses. It is in vain to attempt this by measuring the spectrums themselves; for we cannot be certain of selecting the very same colours for the comparison, because they succeed in an insensible gradation.

The intelligent reader will readily observe, that we have hitherto proceeded on the supposition, that when, by means of contrary refractions, we have united the extreme red and violet rays, we have also united all the others. But this is quite gratuitous. Sir Isaac Newton would, however, have made the same supposition; for he imagined that the different colours divided the spectrum formed by all substances in the proportions of a musical canon. This is a mistake. When a spectrum is formed by a prism of crown-glass, and another of precisely the same length is formed by the side of it by a prism of flint-glass, the confine between the green and blue will be found precisely in the middle of the first spectrum, but in the second it will be considerably nearer to the red extremity. In short, different substances do not disperse the colours in the same proportion.

The effect of this irrationality (so to call it) of dispersion, will appear plainly, we hope, in the following manner: Let A (fig. 9. A) represent a spot of white solar light falling perpendicularly on a wall. Suppose a prism of common glass placed behind the hole through which the light is admitted, with its refracting angle facing the left hand. It will refract the beam of light to the right, and will at the same time disperse this heterogeneous light into its component rays, carrying the extreme red ray from A to R, the extreme orange from A to O, the extreme yellow from A to Y, &c. and will form the usual prismatic spectrum ROYGBPVC. If the whole length RC be divided into 1000 parts, we shall have (when the whole refraction AR is small) RO very nearly 25, RY=200, RG=333, RB=500, RP=667, RV=778, and RC=1000; this being the proportion observed in the differences of the sines of refraction by Sir Isaac Newton.

Perhaps a refracting medium may be found such, that a prism made of it would refract the white light from A, in the upper line of this figure, in such a manner that a spectrum ROYGBPVC shall be formed at the same distance from A, and of the same length, but divided in a different proportion. We do not know that such a medium has been found; but we know that a prism of flint-glass has its refractive and dispersive powers so constituted, that if A'H' be taken about $\frac{1}{3}$ of AR, a spot of white light, formed by rays falling perpendicularly at H', will be so refracted and dispersed, that the extreme red ray will be carried from H' to R', and the extreme violet from H' to C', and the intermediate colours to intermediate points, forming a spectrum resembling the other, but having the colours more confipated towards R', and more dilated towards C; so that the ray which the common glass carried to the middle

point B of the spectrum RC is now in a point B' of the spectrum R'C', considerably nearer to R'. **Telescope.**

Dr Blair has found, on the other hand, that certain fluids, particularly such as contain the muriatic acid, when formed into a prism, will refract the light from H' (in the lower line) so as to form a spectrum R'C' equal to RC, and as far removed from A' as RC is from A, but having the colours more dilated toward R', and more confipated toward C, than is observed in RC; so that the ray which was carried by the prism of common glass to the middle point B is carried to a point B', considerably nearer to C'.

Let us now suppose that, instead of a white spot at A, we have a prismatic spectrum AB (fig. 9. B), and that the prism of common glass is applied as before, immediately behind the prism which forms the spectrum AB. We know that this will be refracted sidewise, and will make a spectrum ROYGBPC, inclined to the plane of refraction in an angle of 45° ; so that drawing the perpendicular RC', we have $RC' = CC'$.

We also know that the prism of flint-glass would refract the spectrum formed by the first prism on EHF, in such a manner that the red ray will go to R, the violet to C, and the intermediate rays to points o, y, g, b, p, v, so situated that O o is = R O' of the other figure; Y y is = R' Y' of that figure, G g = R' G, &c. These points must therefore lie in a curve Ro y g b p v C, which is convex toward the axis R'C'.

In like manner we may be assured that Dr Blair's fluid will form a spectrum R o' y' g' b' p' v' C, concave toward R'C'.

Let it be observed by the way, that this is a very good method for discovering whether a medium disperses the light in the same proportion with the prism which is employed for forming the first spectrum AB or EF. It disperses in the same or in a different proportion, according as the oblique spectrum is straight or crooked; and the exact proportion corresponding to each colour is had by measuring the ordinates of the curves R b C or R b' C.

Having formed the oblique spectrum RBC by a prism of common glass, we know that an equal prism of the same glass, placed in a contrary position, will bring back all the rays from the spectrum RBC to the spectrum AB, laying each colour on its former place.

In like manner, having formed the oblique spectrum R b C by a prism of flint-glass, we know that another prism of flint-glass, placed in the opposite direction, will bring all the rays back to the spectrum EHF.

But having formed the oblique spectrum RBC by a prism of common glass, if we place the flint-glass prism in the contrary position, it will bring the colour R back to E, and the colour C to F; but it will not bring the colour B to H, but to a point b, such that B b is equal to b H, and b B to b H. In like manner, the other colours will not be brought back to the straight line EHF, but to a curve E b F, forming a crooked spectrum.

In like manner, the fluids discovered by Dr Blair, when employed to bring back the oblique spectrum RBC formed by common glass, will bring its extremities back to E and F, and form the crooked spectrum E b' F lying beyond EHF.

This experiment evidently gives us another method for examining the proportionality of the dispersion of different substances.

Having, by common glass, brought back the oblique spectrum formed by common glass to its natural place AB, suppose the original spectrum at AB to contract gradually (as Newton has made it do by means of a lens), it is plain that the oblique spectrum will also contract, and so will the

Telescope. second spectrum at AB; and it will at last coalesce into a white spot. The effect will be equivalent to a gradual compression of the whole figure, by which the parallel lines AR and BC gradually approach, and at last unite.

In like manner, when the oblique spectrum formed by flint-glass is brought back to EHF by a flint-glass prism, and the figure compressed in the same gradual manner, all the colours will coalesce into a white spot.

But when flint-glass is employed to bring back the oblique spectrum formed by common glass, it forms the crooked spectrum E b F. Now let the figure be compressed. The curve E b F will be doubled down on the line H b, and there will be formed a compound spectrum H b, quite unlike the common spectrum, being purple or claret coloured at H by the mixture of the extreme red and violet, and green edged with blue at b by the mixture of the green and blue. The fluid prisms would in like manner form a spectrum of the same kind on the other side of H.

This is precisely what is observed in achromatic object-glasses made of crown-glass and flint: for the refraction from A to R corresponds to the refraction of the convex crown-glass; and the contrary refraction from R to E corresponds to the contrary refraction of the concave flint-glass, which still leaves a part of the first refraction, producing a convergence to the axis of the telescope. It is found to give a purple or wine coloured focus, and within this a green one, and between these an imperfect white. Dr Blair found, that when the eye-glass was drawn out beyond its proper distance, a star was surrounded by a green fringe, by the green end of the spectrum, which crossed each other within the focus; and when the eye-glass was too near the object-glass, the star had a wine-coloured fringe. The green rays were ultimately most refracted. N. B. We should expect the fringe to be of a blue colour rather than a green. But this is easily explained: The extreme violet rays are very faint, so as hardly to be sensible; therefore when a compound glass is made as achromatic as possible to our senses, in all probability (nay certainly) these almost insensible violet rays are left out, and perhaps the extreme colours which are united are the red and the middle violet rays. This makes the green to be the mean ray, and therefore the most outstanding when the dispersions are not proportional.

Dr Blair very properly calls these spectrums, H b and H b', secondary spectrums, and seems to think that he is the first who has taken notice of them. But Mr Clairault was too accurate a mathematician, and too careful an observer, not to be aware of a circumstance which was of primary consequence to the whole inquiry. He could not but observe that the success rested on this very particular, and that the proportionality of dispersion was indispensably necessary.

This subject was therefore touched on by Clairault; and fully discussed by Boscovich, first in his *Dissertations* published at Vienna in 1759; then in the *Comment. Bononiensis*; and, lastly, in his *Opuscula*, published in 1785. Dr Blair, in his ingenious *Dissertation on Achromatic Glasses*, read to the Royal Society of Edinburgh in 1793, seems not to have known of the labours of these writers; speaks of it as a new discovery; and exhibits some of the consequences of this principle in a singular point of view, as something very paradoxical and inconsistent with the usually received notions on these subjects. But they are by no means so. We are, however, much indebted to his ingenious researches, and his successful endeavours to find some remedy for this imperfection of achromatic glasses. Some of his contrivances are exceedingly ingenious; but had the Doctor consulted these writers, he would have saved himself a good deal of trouble.

Boscovich shows how to unite the two extremes with the most outstanding colour of the secondary spectrum, by means of a third substance. When we have done this, the aberration occasioned by the secondary spectrums must be prodigiously diminished; for it is evidently equivalent to the union of the points H and b of our figure. Whatever cause produces this must diminish the curvature of the arches E b and b F: but even if these curvatures were not diminished, their greatest ordinates cannot exceed $\frac{1}{4}$ th of H b; and we may say, without hesitation, that by uniting the mean or most outstanding ray with the two extremes, the remaining dispersion will be as much less than the uncorrected colour of Dollond's achromatic glass, as this is less than four times the dispersion of a common object-glass. It must therefore be altogether insensible.

Boscovich asserts, that it is not possible to unite more than two colours by the opposite refraction of two substances, which do not disperse the light in the same proportions. Dr Blair makes light of this assertion, as he finds it made in general terms in the vague and paltry extract made by Priestley from Boscovich in his *Essay on the History of Optics*; but had he read this author in his own dissertations, he would have seen that he was perfectly right. Dr Blair, however, has hit on a very ingenious and effectual method of producing this union of three colours. In the same way as we correct the dispersion of a concave lens of crown-glass by the opposite dispersion of a concave lens of flint-glass, we may correct the secondary dispersion of an achromatic convex lens by the opposite secondary dispersion of an achromatic concave lens. But the intelligent reader will observe, that this union does not contradict the assertion of Boscovich, because it is necessarily produced by means of three refracting substances.

The most essential service which the public has received at the hands of Dr Blair is the discovery of fluid mediums of a proper dispersive power. By composing the lenses of such substances, we are at once freed from the irregularities in the refraction and dispersion of flint-glass, which the chemists have not been able to free it from. In whatever way this glass is made, it consists of parts which differ both in refractive and dispersive power; and when taken up from the pot, these parts mix in threads, which may be disseminated through the mass in any degree of fineness. But they still retain their properties; and when a piece of flint-glass has been formed into a lens, the eye, placed in its focus, sees the whole surface occupied by glistening threads or broader veins running across it. Great rewards have been offered for removing this defect, but hitherto to no purpose. We beg leave to propose the following method: Let the glass be reduced to powder, and then melted with a great proportion of alkaline salt, so as to make a liquor silicum. When precipitated from this by an acid, it must be in a state of very uniform composition. If again melted into glass, we should hope that it would be free from this defect; if not, the case seems to be desperate.

But by using a fluid medium, Dr Blair was freed from all this embarrassment; and he acquired another immense advantage, that of adjusting at pleasure both the refractive and dispersive powers of his lenses. In solid lenses, we do not know whether we have taken the curvatures suited to the refractions till our glass is finished; and if we have mistaken the proportions, all our labour is lost. But when fluids are used, it is enough that we know nearly the refractions. We suit our focal distances to these, and then select our curvatures, so as to remove the aberration of figure, preserving the focal distances. Thus, by properly tempering the fluid mediums, we bring the lens to agree precisely

Telescope. precisely with the theory, perfectly achromatic, and the aberration of figure as much corrected as is possible.

Dr Blair examined the refractive and dispersive powers of a great variety of substances, and found great varieties in their actions on the different colours. This is indeed what every well informed naturalist would expect. There is no doubt now among naturalists about the mechanical connection of the phenomena of nature; and all are agreed that the chemical actions of the particles of matter are perfectly like in kind to the action of gravitating bodies; that all these phenomena are the effects of forces like those which we call attractions and repulsions, and which we observe in magnets and electrified bodies; that light is refracted by forces of the same kind, but differing chiefly in the small extent of their sphere of activity. One who views things in this way will expect, that as the actions of the same acid for the different alkalis are different in degree, and as the different acids have also different actions on the same alkali, in like manner different substances differ in their general refractive powers, and also in the proportion of their action on the different colours. Nothing is more unlikely therefore than the proportional dispersion of the different colours by different substances; and it is surprising that this inquiry has been so long delayed. It is hoped that Dr Blair will oblige the public with an account of the experiments which he has made. This will enable others to cooperate in the improvement of achromatic glasses. We cannot derive much knowledge from what he has already published, because it was chiefly with the intention of giving a popular, though not an accurate, view of the subject. The constructions which are there mentioned are not those which he found most effectual, but those which would be most easily understood, or demonstrated by the slight theory which is contained in the dissertation; besides, the manner of expressing the difference of refrangibility, perhaps chosen for its paradoxical appearance, does not give us a clear notion of the characteristic differences of the substances examined. Those rays which are ultimately most deflected from their direction, are said to have become the most refrangible by the combination of different substances, although, in all the particular refractions by which this effect is produced, they are less refracted than the violet light. We can just gather this much, that common glass disperses the rays in such a manner, that the ray which is in the confine of the green and blue occupies the middle of the prismatic spectrum; but in glasses, and many other substances, which are more dispersive, this ray is nearer to the ruddy extremity of the spectrum. While therefore the straight line RC' (fig. 9. B) terminates the ordinates Oo' , YY' , Gg' , &c. which represent the dispersion of common glass, the ordinates which express the dispersions of these substances are terminated by a curve passing through R and C' , but lying below the line RC' . When therefore parallel heterogeneous light is made to converge to the axis of a convex lens of common glass, as happens at F in fig. 5. C, the light is dispersed, and the violet rays have a shorter focal distance. If we now apply a concave lens of greater dispersive power, the red and violet rays are brought to one focus F ; but the green rays, not being so much refracted away from F , are left behind at e , and have now a shorter focal distance. But Dr Blair afterwards found that this was not the case with the muriatic acid, and some solutions in it. He found that the ray which common glass caused to occupy the middle of the spectrum was much nearer to

the blue extremity when refracted by these fluids. Therefore a concave lens formed of such fluids which united the red and violet rays in F' , refracted the green rays to f .

Having observed this, it was an obvious conjecture, that a mixture of some of these fluids might produce a medium, whose action on the intermediate rays should have the same proportion that is observed on common glass; or that two of them might be found which formed spectra similarly divided, and yet differing sufficiently in dispersive power to enable us to destroy the dispersion by contrary refractions, without destroying the whole refraction. Dr Blair accordingly found a mixture of solutions of ammoniacal and mercurial salts, and also some other substances, which produced dispersions proportional to that of glass, with respect to the different colours.

And thus has the result of this intricate and laborious investigation corresponded to his utmost wishes. He has produced achromatic telescopes which seem as perfect as the thing will admit of; for he has been able to give them such apertures, that the *incurable* aberration arising from the spherical surfaces becomes a sensible quantity, and precludes farther amplification by the eye-glasses. We have examined one of his telescopes: The focal distance of the object-glass did not exceed 17 inches, and the aperture was fully $3\frac{1}{2}$ inches. We viewed some single and double stars and some common objects with this telescope; and found, that in magnifying power, brightness, and distinctness, it was manifestly superior to one of Mr Dollond's of 42 inches focal length. It also gave us an opportunity of admiring the dexterity of the London artists, who could work the glasses with such accuracy. We had most distinct vision of a star when using an erecting eye piece, which made this telescope magnify more than a hundred times; and we found the field of vision as uniformly distinct as with Dollond's 42 inch telescope magnifying 46 times. The intelligent reader must admire the nice figuring and centering of the very deep eye-glasses which are necessary for this amplification.

It is to be hoped that Dr Blair will extend his views to glasses of different compositions, and thus give us object-glasses which are solid; for those composed of fluids have inconveniences which will hinder them from coming into general use, and will confine them to the museums of philosophers. We imagine that antimonial glasses bid fair to answer this purpose, if they could be made free of colour, so as to transmit enough of light. We recommend this dissertation to the careful perusal of our readers. Those who have not made themselves much acquainted with the delicate and abstruse theory of aberrations, will find it exhibited in such a popular form as will enable them to understand its general aim; and the well-informed reader will find many curious indications of inquiries and discoveries yet to be made.

We now proceed to consider the eye-glasses or glasses of telescopes. The proper construction of an eye-piece is not less essential than that of the object-glass. But our limits will not allow us to treat this subject in the same detail. We have already extended this article to a great length, because we do not know of any performance in the English language which will enable our readers to understand the construction of achromatic telescopes; an invention which reflects honour on our country, and has completed the discoveries of our illustrious Newton. Our readers will find abundant information in Dr Smith's Optics concerning the eye-glasses, chiefly deduced from Huyghen's fine theory of aberration (A). At the same time, we must again pay Mr Dollond

(A) While we thus repeatedly speak of the theory of spherical aberration as coming from Mr Huyghens, we must not omit

Telescope. Dollond the merited compliment of saying, that he was the first who made any scientific application of this theory to the compound eye-piece for erecting the object. His eye-pieces of five and six glasses are very ingenious reduplications of Huyghens's eye-piece of two glasses, and would probably have superseded all others, had not his discovery of achromatic object-glasses caused opticians to consider the chromatic dispersion with more attention, and pointed out methods of correcting it in the eye-piece without any compound eye-glasses. They have found that this may be more conveniently done with four eye-glasses, without sensibly diminishing the advantages which Huyghens showed to result from employing many small refractions instead of a lesser number of great ones. As this is a very curious subject, we shall give enough for making our readers fully acquainted with it, and content ourselves with merely mentioning the principles of the other rules for constructing an eye-piece.

Such readers as are less familiarly acquainted with optical discussions will do well to keep in mind the following consequences of the general focal theorem (OPTICS n° 141. Cor. 5.).

If AB (fig. 10. B) be a lens, R a radiant point or focus of incident rays, and a the focus of parallel rays coming from the opposite side; then,

1. Draw the perpendicular aa' to the axis, meeting the incident ray in a' , and $a'A$ to the centre of the lens. The refracted ray BF is parallel to $a'A$: for $Ra' : a'A (= Ra : aA) = RB : BF (= RA : AF)$, which is the focal theorem.

2. An oblique pencil BPh proceeding from any point P which is not in the axis, is collected to the point f , where the refracted ray BF cuts the line PA, drawn from P through the centre of the lens: for $Pa' : a'A = PB : Bf$, which is also the focal theorem.

The Galilean telescope is susceptible of so little improvement, that we need not employ any time in illustrating its performance.

The simple astronomical telescope is represented in fig. 11. The beam of parallel rays, inclined to the axis, is made to converge to a point G, where it forms an image of the lowest point of a very distant object. These rays decussating from G fall on the eye-glass; the ray from the lowest point B of the object-glass falls on the eye-glass at b ; and the ray from A falls on a ; and the ray from the centre O falls on o . These rays are rendered parallel, or nearly so, by refraction through the eye-glass, and take the direction bi, oi, ai . If the eye be placed so that this pencil of parallel rays may enter it, they converge to a point of the retina, and give distinct vision of the lowest point of the object. It appears inverted, because the rays by which we see its lowest point come in the direction which in simple vision is connected with the upper point of an object. They come from above, and therefore are thought to proceed from above. We see the point as if situated in the direction Io. In like manner the eye placed at I, sees the upper point of the object in the direction IP, and its middle in the direction IE. The proper place for the eye is I: if brought much nearer the glass, or removed much farther

from it, some, or the whole, of this extreme pencil of rays will not enter the pupil. It is therefore of importance to determine this point. Because the eye requires parallel rays for distinct vision, it is plain that F must be the principal focus of the eye-glass. Therefore, by the common focal theorem (OPTICS, n° 141. Cor. 5.), $OF : OE = OE : OI$, or $OF : FE = OE : EI$.

The magnifying power being measured by the magnitude of the visual angle, compared with the magnitude of the visual angle with the naked eye, we have $\frac{oIp}{oOp}$, or $\frac{oIF}{oOF}$ for the measure of the magnifying power. This is very nearly $= \frac{OE}{EI}$, or $\frac{OF}{FI}$.

As the line OE, joining the centres of the lenses, and perpendicular to their surfaces, is called the axis of the telescope, so the ray OG is called the axis of the oblique pencil, being really the axis of the cone of light which has the object-glass for its base. This ray is through its whole course the axis of the oblique pencil; and when its course is determined, the amplification, the field of vision, the apertures of the glasses, are all determined. For this purpose we have only to consider the centre of the object-glass as a radical point, and trace the process of a ray from this point through the other glasses: this will be the axis of some oblique pencil.

It is evident, therefore, that the field of vision depends on the breadth of the eye-glass. Should we increase this, the extreme pencil will pass through I, because O and I are still the conjugate foci of the eye-glass. On the other hand, the angle resolved on for the extent or field of vision gives the breadth of the eye-glass.

We may here observe, by the way, that for all optical instruments there must be two optical figures considered. The first shows the progress of a pencil of rays coming from one point of the object. The various focuses of this pencil show the places of the different images, real or virtual. Such a figure is formed by the three rays AG ai , OG oi , BG bi .

The second shows the progress of the axes of the different pencils proceeding through the centre of the object-glass. The focuses of this pencil of axes show the places where an image of the object-glass is formed; and this pencil determines the field of vision, the apertures of the lenses, and the amplification or magnifying power. The three rays OG oi , OFEI, OHPI, form this figure.

See also fig. 17. where the progress of both sets of pencils is more diversified.

The perfection of a telescope is to represent an object in its proper shape, distinctly magnified, with a great field of vision, and sufficiently bright. But there are limits to all these qualities; and an increase of one of them, for the most part, diminishes the rest. The brightness depends on the aperture of the object-glass, and will increase in the same proportion (because ii' will always be to AB in the proportion of EF to FO), till the diameter of the emergent pencil is equal to that of the pupil of the eye. Increasing the object-glass any more, can send no more light into the eye. But we cannot make the emergent pencil nearly so large

omit giving a due share of the honour of it to Dr Barrow and Mr James Gregory. The first of these authors, in his Optical Lectures delivered at Cambridge, has given every proposition which is employed by Huyghens, and has even prosecuted the matter much further. In particular, his theory of oblique slender pencils is of immense consequence to the perfection of telescopes, by showing the methods for making the image of an extended surface as flat as possible. Gregory, too, has given all the fundamental propositions in his *Optica Promota*. But Huyghens, by taking the subject together, and treating it in a system, has greatly simplified it: and his manner of viewing the principal parts of it is incomparably more perspicuous than the performances of Barrow and Gregory.

Telescope. large as this when the telescope magnifies much; for the great aperture of the object-glass produces an indistinct image at GF, and its indistinctness is magnified by the eye-glass.

A great field of vision is incompatible with the true shape of the object; for it is not strictly true that all rays flowing from O are refracted to I. Those rays which go to the margin of the eye-glass cross the axis between E and I; and therefore they cross it at a greater angle than if they passed through I. Now had they really passed through I, the object would have been represented in its due proportions. Therefore since the angles of the marginal parts are enlarged by the aberration of the eye-glass, the marginal parts themselves will appear enlarged, or the object appear distorted. Thus a chess-board viewed through a reading glass appears drawn out at the corners, and the straight lines are all changed into curves, as is represented in fig. 13.

The circumstance which most peremptorily limits the extent of field is the necessary distinctness. If the vision be indistinct, it is useless, and no other quality can compensate this defect. The distortion is very inconsiderable in much larger angles of vision than we can admit, and is unworthy of the attention paid to it by optical writers. They have been induced to take notice of it, because the means of correcting it in a considerable degree are attainable, and afford an opportunity of exhibiting their knowledge; whereas the indistinctness which accompanies a large field is a subject of most difficult discussion, and has hitherto baffled all their efforts to express by any intelligible or manageable formulæ.

*Quæque tractata nitescere posse
Desperat relinquit.*

This subject must, however, be considered. The image at GF of a very remote object is not a plain surface perpendicular to the axis of the telescope, but is nearly spherical, having O for its centre. If a number of pencils of parallel rays crossing each other in I fall on the eye-glass, they will form a picture on the opposite side, in the focus F. But this picture will by no means be flat, nor nearly so, but very concave towards E. Its exact form is of most difficult investigation. The elements of it are given by Dr Barrow; and we have given the chief of them in the article OPTICS, when considering the foci of infinitely slender pencils of oblique rays. Therefore it is impossible that the picture formed by the object-glass can be seen distinctly in all its parts by the eye-glass. Even if it were flat, the points G and H (fig. 11.) are too far from the eye-glass when the middle F is at the proper distance for distinct vision. When, therefore, the telescope is so adjusted that we have distinct vision of the middle of the field, in order to see the margin distinctly we must push in the eye-glass: and having so done, the middle of the field becomes indistinct. When the field of vision exceeds 12 or 15 degrees, it is not possible by any contrivance to make it tolerably distinct all over; and we must turn the telescope successively to the different parts of the field that we may see them agreeably.

The cause of this indistinctness is, as we have already said, the shortness of the lateral foci of lateral and oblique pencils refracted by the eye-glass. We have shown (in OPTICS, n° 252) how to determine these in all the cases which occur. But the determination is not complete, and relates only to those rays which are in a plane passing through the axis of the lens. But the oblique pencil bGa , by which an eye placed at I sees the point G of the image, is a cone of light, having a circular base on the eye-glass; of which circle ab is one of the diameters. There is a diameter perpendicular to this, which, in this figure, is represented by the point o . Fig. 12. represents the base of the cone as seen by an eye

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placed in the axis of the telescope, with the object-glass as appearing behind it. The point b is formed by a ray which comes from the lowest point B of the object-glass, and the point a is illuminated by a ray from A. The point c at the right-hand of the circular base of this cone of light came from the point C on the left side of the object-glass; and the light comes to d from D. Now the laws of optics demonstrate, that the rays which come through the points c and d are more convergent after refraction than the rays which come through a and b . The analogies, therefore, which ascertain the foci of rays lying in planes passing thro' the axis do not determine the foci of the others. Of this we may be sensible by looking through a lens to a figure on which are drawn concentric circles crossed by radii. When the telescope is so adjusted that we see distinctly the extremity of one of the radii, we shall not see distinctly the circumference which crosses the extremity with equal distinctness, and *vice versa*. This difference, however, between the foci of the rays which come through a and b , and those which come through c and d , is not considerable in the fields of vision, which are otherwise admissible. But the same difference of foci obtains also with respect to the dispersion of light, and is more remarkable. Both d'Alembert and Euler have attempted to introduce it into their formulæ; but they have made them useless for any practical purpose by their inextricable complication.

This must serve as a general indication of the difficulties which occur in the construction of telescopes, even although the object-glass were perfect, forming an image without the smallest confusion or distortion.

There is yet another difficulty or imperfection. The rays of the pencil aGb , when refracted through the eye-glass, are also separated into their component colours. The edge of the lens must evidently perform the office of a prism, and the white ray Gb will be so dispersed that if bi be the path of its red ray, the violet ray, which makes another part of it, will take such a course bn that the angle $i'bn$ will be nearly $\frac{1}{17}$ th of Gbi . The ray Ga passing through a part of the lens whose surfaces are less inclined to each other, will be less refracted, and will be less dispersed in the same proportion very nearly. Therefore the two violet rays will be very nearly parallel when the two red rays are rendered parallel.

Hence it must happen, that the object will appear bordered with coloured fringes. A black line seen near the margin on a white ground, will have a ruddy and orange border on the outside and a blue border within: and this confusion is altogether independent on the object-glass, and is so much the greater as the visual angle bIE is greater.

Such are the difficulties: They would be unsurmountable were it not that some of them are so connected that, to a certain extent, the diminution of one is accompanied by a diminution of the other. Our readers will recollect, that in the article OPTICS we gave some account of what are called the *Cautic curves* (OPTICS n° 252), and showed that these curves are the geometrical loci of the foci of infinitely slender pencils. Consequently the point G is very nearly in the caustic formed by a beam of light consisting of rays parallel to Io , and occupying the whole surface of the eye-glass, because the pencil of rays which are collected at G is very small. Any thing therefore that diminishes the mutual inclination of the adjoining rays, puts their concurrence farther off. Now this is precisely what we want: for the point G of the image formed by the object-glass is already beyond the focus of the oblique slender pencil of parallel rays ia and ib ; and, therefore, if we could make this focus go a little farther from a and b , we shall bring it nearer to G, and obtain more distinct vision of this point of the object. Now

Z z

let

Telescope. let it be recollected, that in moderate refractions through prisms, two rays which are inclined to each other in a small angle are, after refraction, inclined to each other in the same angle. Therefore, if we can diminish the aberration of the ray ai , or oI , or bi , we diminish their mutual inclination; and consequently the mutual inclination of the rays Ga , Go , Gb , and therefore lengthen the focus, and get more distinct vision of the point G . Therefore we at once correct the distortion and the indistinctness: and this is the aim of Mr Huyghens's great principle of dividing the refractions. See OPTICS, n° 100.

The general method is as follows: Let o be the object-glass (fig. 14. A) and E the eye-glass of a telescope, and F their common focus, and FG the image formed by the object-glass. The proportion of their focal distances is supposed to be such as gives as great a magnifying power as the perfection of the object-glass will admit. Let BI be the axis of the emergent pencil. It is known by the focal theorem that GE is parallel to BI : therefore BGE is the whole refraction or deflection of the ray OHB from its former direction. Let it be proposed to diminish the aberrations by dividing this into two parts by means of two glasses D and e , so as to make the ultimate angle of vision bie equal to BIE , and thus retain the same magnifying power and visible field. Let it be proposed to divide it into the parts BGC and CGE .

From G draw any line GD to the axis towards O ; and draw the perpendicular DH , cutting OG in H ; draw Hc parallel to GC , cutting GD in g ; draw gf perpendicular to the axis, and ge parallel to GE ; draw eb perpendicular to the axis; draw Dd parallel to GC , and dd perpendicular to the axis.

Then if there be placed at D a lens whose focal distance is Dd , and another at e whose focal distance is ef , the thing is done. The ray OH will be refracted into Hb , and this into bie parallel to BI .

The demonstration of this construction is so evident by means of the common focal theorem, that we need not repeat it, nor the reasons for its advantages (see OPTICS 100). We have the same magnifying power, and the same field of vision; we have less aberration, and therefore less distortion and indistinctness; and this is brought about by a lens HD of a smaller aperture and a greater focal distance than BE . Consequently, if we are contented with the distinctness of the margin of the field with a single eye-glass, we may greatly increase the field of vision: for if we increase DH to the size of EB we shall have a greater field, and much greater distinctness in the margin; because HD is of a longer focal distance, and will bear a greater aperture, preserving the same distinctness at the edge. On this account the glass HD is commonly called the *Field-glass*.

It must be observed here, however, that although the distortion of the object is lessened, there is a real distortion produced in the the image fg . But this, when magnified by the glass e , is smaller than the distortion produced by the glass E , of greater aperture and shorter focus, on the undistorted image GF . But because there is a distortion in the second image fg , this construction cannot be used for the telescopes of astronomical quadrants, and other graduated instruments; because then equal divisions of the micrometer would not correspond to equal angles.

But the same construction will answer in this case, by taking the point D on that side of F which is remote from O (fig. 14. B). This is the form now employed in the telescopes of all graduated instruments.

The exact proportion in which the distortion and the indistinctness at the edges of the field are diminished by this construction, depends on the proportion in which the angle

Telescope. BGE is divided by GC ; and is of pretty difficult investigation. But it never deviates far (never $\frac{1}{4}$ th in optical instruments) from the proportion of the squares of the angles. We may, without any sensible error, suppose it in this proportion. This gives us a practical rule of easy recollection, and of most extensive use. When we would diminish an aberration by dividing the whole refraction into two parts, we shall do it most effectually by making them equal. In like manner, if we divide it into three parts by means of two additional glasses, we must make each $= \frac{1}{3}$ d of the whole; and so on for a greater number.

This useful problem, even when limited, as we have done, to equal refractions, is as yet indeterminate; that is, susceptible of an infinity of solutions: for the point D , where the field-glass is placed, was taken at pleasure: yet there must be situations more proper than others. The aberrations which produce distortion, and those which produce indistinctness, do not follow the same proportions. To correct the indistinctness, we should not select such positions of the lens HD as will give a small focal distance to be ; that is, we should not remove it very far from F . Huygens recommends the proportion of 3 to 1 for that of the focal distances of the lens HD and eb , and says that the distance De should be $= 2 Fe$. This will make $ei = \frac{1}{2} eF$, and will divide the whole refraction into two equal parts, as any one will readily see by constructing the common optical figure. Mr Short, the celebrated improver of reflecting telescopes, generally employed this proportion; and we shall presently see that it is a very good one.

It has been already observed that the great refractions which take place on the eye-glasses occasion very considerable dispersions, and disturb the vision by fringing every thing with colours. To remedy this, achromatic eye-glasses may be employed, constructed by the rules already delivered. This construction, however, is incomparably more intricate than that of object-glasses: for the equations must involve the distance of the radiant point, and be more complicated: and this complication is immensely increased on account of the great obliquity of the pencils.

Most fortunately the Huyghenian construction of an eyepiece enables us to correct this dispersion to a great degree of exactness. A heterogeneous ray is dispersed at H , and the red ray belonging to it falls on the lens be at a greater distance from the centre than the violet ray coming from H . It will therefore be less refracted (*cæteris paribus*) by the lens be ; and it is possible that the difference may be such that the red and violet rays dispersed at H may be rendered parallel at b , or even a little divergent, so as to unite accurately with the red ray at the bottom of the eye. How this may be affected, by a proper selection of the places and figures of the lenses, will appear by the following proposition, which we imagine is new, and not inelegant.

Let the compound ray OP (fig. 15. A) be dispersed by the lens PC ; and let PV , PR be its violet and red rays, cutting the axis in G and g . It is required to place another lens RD in their way, so that the emergent rays Rr , Vv , shall be parallel.

Produce the incident ray OP to Z . The angles ZPR , ZPV , are given, (and RPV is nearly $= \frac{ZPR}{27}$) and the intersections G and g with the axis. Let F be the focus of parallel red light coming through the lens RD in the opposite direction. Then (by the common optical theorem), the perpendicular Fp will cut PR in such a point p , that pF will be parallel to the emergent ray Rr (see OPTICS, n° 252—256), and to Vv . Therefore if pD cut PV in u , and uf be drawn perpendicular to the axis, we shall have (also by the common theorem) the point f for the focus of violet

Telescope. violet rays, and $DF : Df = Dp : Du = 28 : 27$ nearly, or in a given ratio.

The problem is therefore reduced to this, "To draw from a point D in the line CG a line Dp , which shall be cut by the lines PR and PV in the given ratio.

The following construction naturally offers itself: Make $GM : gM$ in the given ratio, and draw MK parallel to Pg . Through any point D of CG draw the straight line PDK, cutting MK in K. Join GK, and draw Dp parallel to KG. This will solve the problem; and, drawing pF perpendicular to the axis, we shall have F for the focus of the lens RD for parallel red rays.

The demonstration is evident: for MK being parallel to Pg , we have $GM : gM = GK : HK, = pD : uD, = FD : fD$, in the ratio required.

This problem admits of an infinity of solutions; because the point D may be taken anywhere in the line CG. It may therefore be subjected to such conditions as may produce other advantages.

1. It may be restricted by the magnifying power, or by the division which we choose to make of the whole refraction which produces this magnifying power. Thus, if we have resolved to diminish the aberrations by making the two refractions equal, we have determined the angle RrD . Therefore draw GK, making the angle MGK equal to that which the emergent pencil must make with the axis, in order to produce this magnifying power. Then draw MK parallel to Pg , meeting GK in K. Then draw PK, cutting the axis in D, and Dp parallel to GK, and pF perpendicular to the axis. D is the place, and DF the focal distance of the eye-glass.

2. Particular circumstances may cause us to fix on a particular place D, and we only want the focal distance. In this case the first construction suffices.

3. We may have determined on a certain focal distance DF, and the place must be determined. In this case let

$$GF : Fp = 1 : \tan. G$$

$$Fp : fu = 1 : m, m \text{ being } = \frac{2}{3}$$

$$fu : fg = \tan. g : 1$$

$$\text{then } GF : fg = \tan. g : m \tan. G$$

$$\text{then } GF - fg : GF = \tan. g - m \tan. G : \tan. g$$

$$\text{or } Gg + Ff : GF = \tan. g - m \tan. G : \tan. g;$$

$$\text{and } GF = Gg + Ff \frac{\tan. g}{\tan. g - m \tan. G}, \text{ and is there-}$$

fore given, and the place of F is determined; and since FD is given by supposition, D is determined.

The application of this problem to our purpose is difficult, if we take it in the most general terms; but the nature of the thing makes such limitations that it becomes very easy. In the case of the dispersion of light, the angle GPg is so small that MK may be drawn parallel to PG without any sensible error. If the ray OP were parallel to CG, then G would be the focus of the lens PC, and the point M would fall on C; because the focal distance of red rays is to that of violet rays in the same proportion for every lens, and therefore $CG : Cg = DF : Df$. Now, in a telescope which magnifies considerably, the angle at the object-glass is very small, and CG hardly exceeds the focal distance; and CG is to Cg very nearly in the same proportion of 28 to 27. We may therefore draw through C (fig. 15. B) a line CK parallel to PG: then draw GK' perpendicular to the axis of the lenses, and join PK'; draw K'BE parallel to CG, cutting PK in B; draw BHI parallel to GK, cutting GK' in H: Join HD and PK. It is evident that CG is bisected in F, and that $K'B = 2FD$: also $K'H : HG = K'B : BE, = CD : DG$. Therefore DH is parallel to CK', or to PG. But because $PF = F'K'$, PD is $= DB$, and $IH = HB$. Therefore $pD = HB$, and $FD = K'B$,

$$= 2FD; \text{ and } FD \text{ is bisected in } F. \text{ Therefore } CD = \frac{CG + FD}{2} \text{ Telescope.}$$

That is, in order that the eye-glass RD may correct the dispersion of the field-glass PC, the distance between them must be equal to the half sum of their focal distances very nearly. More exactly, the distance between them must be equal to the half sum of the focal distance of the eye-glass, and the distance at which the field-glass would form an image of the object-glass. For the point G is the focus to which a ray coming from the centre of the object-glass is refracted by the field-glass.

This is a very simple solution of this important problem. Huyghens's eye-piece corresponds with it exactly. If indeed the dispersion at P is not entirely produced by the refraction, but perhaps combined with some previous dispersion, the point M (fig. 15. A) will not coincide with C, (fig. 15. B), and we shall have GC to GM, as the natural dispersion at P to the dispersion which really obtains there.

$$\text{This may destroy the equation } CD = \frac{CG + FD}{2}.$$

Thus, in a manner rather unexpected, have we freed the eye-glasses from the greatest part of the effect of dispersion. We may do it entirely by pushing the eye-glass a little nearer to the field-glass. This will render the violet rays a little divergent from the red, so as to produce a perfect picture at the bottom of the eye. But by doing so we have hurt the distinctness of the whole picture, because F is not in the focus of RD. We remedy this by drawing both glasses out a little, and the telescope is made perfect.

This improvement cannot be applied to the construction of quadrant telescopes, such as fig. 14. B. Mr Ramsden has attempted it, however, in a very ingenious way, which merits a place here, and is also instructive in another way. The field-glass HD (fig. 14. B) is a plano-convex, with its plane side next the image GF. It is placed very near this image. The consequence of this disposition is, that the image GF produces a vertical image gf , which is much less convex towards the glass. He then places a lens on the point C, where the red ray would cross the axis. The violet ray will pass on the other side of it. If the focal distance of this glass be fc , the vision will be distinct and free from colour. It has, however, the inconveniency of obliging the eye to be close to the glass, which is very troublesome.

This would be a good construction for a magic-lantern, or for the object-glass of a solar microscope, or indeed of any compound microscope.

We may presume that the reader is now pretty familiar with the different circumstances which must be considered in the construction of an eye-piece, and proceed to consider those which must be employed to erect the object.

This may be done by placing the lens which receives the light from the object-glass in such a manner, that a second image (inverted with respect to the first) may be formed beyond it, and this may be viewed by an eye-glass. Such a construction is represented in fig. 16. But, besides many other defects, it tinges the object prodigiously with colour. The ray od is dispersed at d into the red ray dr , and the violet dv , v being farther from the centre than r , the refracted ray vv' crosses rr' both by reason of spherical aberration and its greater refrangibility.

But the common day telescope, invented by F. Rheita, has, in this respect, greatly the advantage of the one now described. See OPTICS, n° 266. The rays of compound light are dispersed at e and f . (Plate CCCLXIV. fig. 13). The violet ray proceeding from f , falls without the red ray at g , but is accurately collected with it at the focus E, as we shall demonstrate by and by. Since they cross each other

Telescope. other in E, the violet ray must fall within the red ray at i , and be less refracted than if it had fallen on the same point with the red ray. Had it fallen there it would have separated from it; but by a proper diminution of its refraction, it is kept parallel to it, or nearly so. And this is one excellence of this telescope: when constructed with three eye-glasses perfectly equal, the colour is sensibly diminished, and by using an eye-glass somewhat smaller, it may be removed entirely. — We say no more of it at present, because we shall find its construction included in another, which is still more perfect.

It is evident at first sight that this telescope may be improved, by substituting for the eye-glass ik (fig. 13.) the Huyghenian double eye-glass, or field-glass and eye-glass represented in fig. 14. A, and fig. 14. B; and that the first of these may be improved and rendered achromatic. This will require the two glasses ef and gb to be increased from their present dimensions to the size of a field-glass, suited to the magnifying power of the telescope, supposing it an astronomical telescope. Thus we shall have a telescope of four eye-glasses. The three first will be of a considerable focal distance, and two of them will have a common focus at b . But this is considerably different from the eye-piece of four glasses which are now used, and are far better. We are indebted for them to Mr Dollond, who was a mathematician as well as an artist, and in the course of his research discovered resources which had not been thought of. He had not then discovered the achromatic object-glass, and was busy in improving the eye-glasses by diminishing their spherical aberration. His first thought was to make the Huyghenian addition at both the images of the day telescope. This suggested to him the following eye-piece of five glasses.

Plate
DIV.

Fig. 17. represents this eye-piece, but there is not room for the object-glass at its proper distance. A pencil of rays coming from the upper point of the object is made to converge (by the object-glass) to G , where it would form a picture of that part of the object. But it is intercepted by the lens Aa , and its axis is bent towards the axis of the telescope in the direction ab . At the same time, the rays which converged to G converge to g , and there is formed an inverted picture of the object at gf . The axis of the pencil is again refracted at b , crosses the axis of the telescope in H , is refracted again at c , at d , and at e , and at last crosses the axis in I . The rays of this pencil, diverging from g , are made less diverging, and proceed as if they came from g' , in the line Bgg' . The lens cC causes them to converge to g' , in the line $G'Cg'$. The lens dD makes them converge still more to G'' , and there they form an erect picture $G''F''$; diverging from G'' , they are rendered parallel by the refraction at e .

At H the rays are nearly parallel. Had the glass Bb been a little farther from A , they would have been accurately so, and the object-glass, with the glasses A and B , would have formed an astronomical telescope with the Huyghenian eye-piece. The glasses C , D , and E , are intended merely for bending the rays back again till they again cross the axis in I . The glass C tends chiefly to diminish the great angle BHb ; and then the two glasses D and E are another Huyghenian eye-piece.

The art in this construction lies in the proper adjustment of the glasses, so as to divide the whole bending of the pencil pretty equally among them, and to form the last image in the focus of the eye-glass, and at a proper distance from the other glass. Bringing B nearer to A would bend the pencil more to the axis. Placing C farther from B would do the same thing; but this would be accompanied with more aberration, because the rays would fall at a greater di-

stance from the centres of the lenses. The greatest bending is made at the field-glass D ; and we imagine that the telescope would be improved, and made more distinct at the edges of the field, by employing another glass of great focal distance between C and D .

There is an image formed at H of the object-glasses, and the whole light passes through a small circle in this place. It is usual to put a plate here pierced with a hole which has the diameter of this image. A second image of the object-glass is formed at I , and indeed wherever the pencils cross the axis. A lens placed at H makes no change in any of the angles, nor in the magnifying power, and affects only the place where the images are formed. And, on the other hand, a lens placed at f , or F'' , where a real image is formed, makes no change in the places of the images, but affects the mutual inclination of the pencils. This affords a resource to the artist, by which he may combine properties which seem incompatible.

The aperture of A determines the visible field and all the other apertures.

We must avoid forming a real image, such as fg , or $F'G''$, on or very near any glass. For we cannot see this image without seeing along with it every particle of dust and every scratch on the glass. We see them as making part of the object when the image is exactly on the glass, and we see them confusedly, and so as to confuse the object, when the image is near it. For when the image is on or very near any glass, the pencil of light occupies a very small part of its surface, and a particle of dust intercepts a great proportion of it.

It is plain that this construction will not do for the telescope of graduated instruments, because the micrometer cannot be applied to the second image fg , on account of its being a little distorted, as has been observed of the Huyghenian eye-piece.

Also the interposition of the glass C makes it difficult to correct the dispersion.

By proper reasoning from the correction in the Huyghenian eye-piece, we are led to the best construction of one with three glasses; which we shall now consider, taking it in a particular form, which shall make the discussion easy, and make us fully masters of the principles which lead to a better form. Therefore let PA (fig. 18.) be the glass which first receives the light proceeding from the image formed by the object-glass, and let OP be the axis of the extreme pencil. This is refracted into PR , which is again refracted into Rr by the next lens B . Let b be the focus of parallel rays of the second lens. Draw PBr . We know that $Ab:bB = PB:Br$, and that rays of one kind diverging from P will be collected at r . But if PR , PV be a red and a violet ray, the violet ray will be more refracted at V , and will cross the red ray in some intermediate point g of the line Rr . If therefore the first image had been formed precisely on the lens PA , we should have a second image at fg free from all coloured fringes.

If the refractions at P and R are equal (as in the common day telescope), the dispersion at V must be equal to that at P , or the angle $\angle VPr = \angle VPR$. But we have ultimately $RPV:RrV = BC:AB$, ($= Bb:Ab$ by the focal theorem). Therefore $gVr:grV$ (or $gr:gV$, or $Cf:fB$) $= Bb:Ab$, and $AB:Ab = Rr:Rg$.

This shows by the way the advantage of the common day telescope. In this $AB = 2Ab$, and therefore f is the place of the last image which is free from coloured fringes. But this image will not be seen free from coloured fringes through the eye-glass Cr , if f be its focus: For had gr , gv been both red rays, they would have been parallel after refraction; but gv being a violet ray, will be more refracted. It will

Telescope. will not indeed be so much deflected from parallelism as the violet ray, which naturally accompanies the red ray to r , because it falls nearer the centre. By computation its dispersion is diminished about $\frac{1}{7}$ th.

In order that gv may be made parallel to gr after refraction, the refraction at r must be such that the dispersion corresponding to it may be of a proper magnitude. How to determine this is the question. Let the dispersion at g be to the dispersion produced by the refraction at r (which is required for producing the intended magnifying power) as 1 to 9. Make $9:1 = ff':f'C, = fC:CD$, and draw the perpendicular $D'r'$ meeting the refracted ray rr' in r' . Then we know by the common focal theorem, that if f be the focus of the lens C , red rays diverging from g will be united in r' . But the violet ray gv will be refracted into $v'v'$ parallel to rr' . For the angle $vr'r:vg'r =$ (ultimately) $fC:CD, = 9:1$. Therefore the angle $vr'r$ is equal to the dispersion produced at r , and therefore equal to $r'v'v'$, and $v'v'$ is parallel to rr' .

But by this we have destroyed the distinct vision of the image formed at fg , because it is no longer at the focus of the eye-glass. But distinct vision will be restored by pushing the glasses nearer to the object-glass. This makes the rays of each particular pencil more divergent after refraction through A , but scarcely makes any change in the directions of the pencils themselves. Thus the image comes to the focus f' , and makes no sensible change in the dispersions.

In the common day telescope, the first image is formed in the anterior focus of the first eye-glass, and the second image is at the anterior focus of the last eye-glass. If we change this last for one of half the focal distance, and push in the eye-piece till the image formed by the object-glass is half way between the first eye-glass and its focus, the last image will be formed at the focus of the new eye-glass, and the eye-piece will be achromatic. This is easily seen by making the usual computations by the focal theorem. But the visible field is diminished, because we cannot give the same aperture as before to the new eye-glass; but we can substitute for it two eye-glasses like the former, placed close together. This will have the same focal distance with the new one, and will allow the same aperture that we had before.

On these principles may be demonstrated the correction of colour in eye-pieces with three glasses of the following construction.

Let the glasses A and B be placed so that the posterior focus of the first nearly coincides with the anterior focus of the second, or rather so that the anterior focus of B may be at the place where the image of the object-glass is formed; by which situation the aperture necessary for transmitting the whole light will be the smallest possible. Place the third C at a distance from the second, which exceeds the sum of their focal distances by a space which is a third proportional to the distance of the first and second, and the focal distance of the second. The distance of the first eye-glass from the object-glass must be equal to the product of the focal distance of the first and second divided by their sum.

Let O, a, b, c , the focal distances of the glasses, be O, a, b, c . Then make $AB = a + b$ nearly; $BC = b + c + \frac{b^2}{b+c}$; $OA = \frac{bc}{b+c}$. The amplification or magnifying power will be $= \frac{ob}{ac}$; the equivalent eye-glass $= \frac{ac}{b}$; and the field of vision $= 3438' \times \frac{\text{Aperture of } A}{\text{foc. dist. ob. gl.}}$

Telescope. These eye-pieces will admit the use of a micrometer at the place of the first image, because it has no distortion.

Mr Dollond was anxious to combine this achromatism of the eye-pieces with the advantages which he had found in the eye-pieces with five glasses. This eye-piece of three glasses necessarily has a very great refraction at the glass B , where the pencil which has come from the other side of the axis must be rendered again convergent, or at least parallel to it. This occasions considerable aberrations. This may be avoided by giving part of this refraction to a glass put between the first and second, in the same way as he has done by the glass B put between A and C in his five glass eye-piece. But this deranges the whole process. His ingenuity, however, surmounted this difficulty, and he made eye-pieces of four glasses, which seem as perfect as can be desired. He has not published his ingenious investigation; and we observe the London artists work very much at random, probably copying the proportions of some of his best glasses, without understanding the principle, and therefore frequently mistaking. We see many eye-pieces which are far from being achromatic. We imagine therefore that it will be an acceptable thing to the artists to have precise instructions how to proceed, nothing of this kind having appeared in our language, and the investigations of Euler, D'Alembert, and even Boscovich, being so abstruse as to be inaccessible to all but experienced analysts. We hope to render it extremely simple.

It is evident, that if we make the rays of different colours unite on the surface of the last eye-glass but one, commonly called the *field-glass*, the thing will be done, because the dispersion from this point of union will then unite with the dispersion produced by this glass alone; and this increased dispersion may be corrected by the last eye-glass in the way already shown.

Therefore let A, B (fig. 19.) be the stations which we have fixed on for the first and second eye-glasses, in order to give a proper portion of the whole refraction to the second glass. Let b be the anterior focus of B . Draw PBr through the centre of B . Make $Ab:bB = AB:BK$. Draw the perpendicular Kr , meeting the refracted ray in r . We know by the focal theorem, that red rays diverging from P will converge to r ; but the violet ray PV , being more refracted, will cross Rr in some point g . Drawing the perpendicular fg , we get f for the proper place of the field-glass. Let the refracted ray Rr , produced backwards, meet the ray OP coming from the centre of the object-glass in O . Let the angle of dispersion RPV be called p , and the angle of dispersion at V , that is, rVv , be v , and the angle VrR be r .

It is evident that $OR:OP = p:v$, because the dispersions are proportional to the sines of the refractions, which, in this case, are very nearly as the refractions themselves.

Let $\frac{OP}{OR}$ (or $\frac{op}{pB}$ or $\frac{pB}{bB}$) be made $= m$. Then $v =$

mp ; also $p:r = BK:AB, = bB:Ab$, and $r = p \cdot \frac{Ab}{bB}$,

or, making $\frac{Ab}{bB} = n$, $r = np$; therefore $v:r = m:n, =$

$\frac{pB}{bB} : \frac{Ab}{bB}, = pB:Ab$.

The angle $RgV = gVr + grV = p \cdot \overline{m+n}$; and $RgV:Rrv = Rr:Rg$, or $m+n:n = Rr:Rg$, and

$Rg = Rr \frac{n}{m+n}$. But Rr is ultimately $= BK = AB$

bB

Telescope. $\frac{bB}{Ab} = \frac{AB}{n}$. Therefore $Rg = \frac{AB}{n} \times \frac{n}{m+n} = \frac{AB}{m+n}$,
and $Bf = \frac{AB}{m+n}$.

This value of Bf is evidently $= bB \times \frac{AB}{pB + Ab}$.
Now bB being a constant quantity while the glass B is the same, the place of union varies with $\frac{AB}{pB + Ab}$. If we remove B a little farther from A , we increase AB , and pB , and Ab , each by the same quantity. This evidently diminishes Bf . On the other hand, bringing B nearer to A increases Bf . If we keep the distance between the glasses the same, but increase the focal distance bB , we augment Bf , because this change augments the numerator and diminishes the denominator of the fraction $\frac{bB \times AB}{pB + Ab}$.

In this manner we can unite the colours at what distance we please, and consequently can unite them in the place of the intended field-glass, from which they will diverge with an increased dispersion, viz. with the dispersion competent to the refraction produced there, and the dispersion $p \times \frac{AB}{m+n}$ conjoined.

It only remains to determine the proper focal distances of the field-glass and eye-glass, and the place of the eye-glass, so that this dispersion may be finally corrected.

This is an indeterminate problem, admitting of an infinity of solutions. We shall limit it by an equal division of the two remaining refractions, which are necessary in order to produce the intended magnifying power. This construction has the advantage of diminishing the aberration. Thus we know the two refractions, and the dispersion competent to each; it being nearly $\frac{1}{2}$ th of the refraction. Call this q . The whole dispersion at the field-glass consists of q , and of the angle KgV of fig. 19. which we also know to be $= p \times \frac{AB}{m+n}$. Call their sum s .

Let fig. 20. n° 1. represent this addition to the eye-piece. Cg is the field-glass coming in the place of fg of fig. 19. and Rgw is the red ray coming from the glass BR . Draw gs parallel to the intended emergent pencil from the eye-glass; that is, making the angle Csg with the axis correspond to the intended magnifying power. Bisect this angle by the line gK . Make $sg:gg=s:q$, and draw gK , cutting Cg in t . Draw td , cutting gk in i , and the axis in D . Draw dd and Dr perpendicular to the axis. Then a lens placed in D , having the focal distance Dd , will destroy the dispersion at the lens gc , which refracts the ray gw into gr .

Let gv be the violet ray, making the angle $vgv = s$. It is plain, by the common optical theorem, that gr will be refracted into rr' parallel to td . Draw gDr' meeting rr' , and join vr' . By the focal theorem two red rays gr , gv , will be united in r' . But the violet ray gv will be more refracted, and will take the path vv' , making the angle of dispersion $r'vv' = q$, very nearly, because the dispersion at v does not sensibly differ from that at r . Now, in the small angles of refraction which obtain in optical instruments, the angles $rr'v$, rgv are very nearly as gr and rr' , or as gD and Dr' , or as CD and DT ; which, by the focal theorem, are as Cd and dD ; that is, $Dd:dc = rgv:rr'v$. But $Dd:dc = Dd:dt = sg:gq = s:q$. But $rgv = s$; therefore $rr'v = q = r'vv'$, and vv' is parallel to rr' , and the whole dispersion at g is corrected by the lens Dr . The focal distance Cc of Cg is had by drawing Cx parallel to Kg , meeting Rg in x , and drawing xc perpendicular to the axis.

It is easy to see that this (not inelegant) construction is

not limited to the equality of the refractions wgr , Krr' . Telescope. In whatever proportion the whole refraction wgs is divided, we always can tell the proportion of the dispersions which the two refractions occasion at g and r , and can therefore find the values of s and q . Indeed this solution includes the problem in p. 365. col. 1. par. 2.; but it had not occurred to us till the present occasion. Our readers will not be displeased with this variety of resource.

The intelligent reader will see, that in this solution some quantities and ratios are assumed as equal which are not strictly so, in the same manner as in all the elementary optical theorems. The parallelism, however, of vv' and rr' may be made accurate, by pushing the lens Dr nearer to Cg , or retiring it from it. We may also, by pushing it still nearer, induce a small divergency of the violet ray, so as to produce accurate vision in the eye, and may thus make the vision through a telescope more perfect than with the naked eye, where dispersion is by no means avoided. It would therefore be an improvement to have the eye-glass in a sliding tube for adjustment. Bring the telescope to distinct vision; and if any colour be visible about the edges of the field, shift the eye-glass till this colour is removed. The vision may now become indistinct: but this is corrected by shifting the place of the whole eye-piece.

We have examined trigonometrically the progress of a red and a violet ray through many eye-pieces of Dollond's and Ramsden's best telescopes; and we have found in all of them that the colours are united on or very near the field-glass; so that we presume that a theory somewhat analogous to ours has directed the ingenious inventors. We meet with many made by other artists, and even some of theirs, where a considerable degree of colour remains, sometimes in the natural order and often in the contrary order. This must happen in the hands of mere imitators, ignorant of principle. We presume that we have now made this principle sufficiently plain.

Fig. 20. N° 2. represents the eye-piece of a very fine spy-glass by Mr Ramsden; the focal length of its object-glass is $8\frac{1}{2}$ inches, with $1\frac{1}{8}$ th of aperture, $2^\circ 05'$ of visible field, and 15.4 magnifying power. The distances and focal lengths are of their proper dimensions, but the apertures are $\frac{1}{2}$ larger, that the progress of a lateral pencil might be more distinctly drawn. The dimensions are as follow:

Foc. lengths $Aa=0.775$ $Bb=1.025$ $Cc=1.01$ $Dd=0.79$
Distances $AB=1.18$ $BC=1.83$ $CD=1.105$.

It is perfectly achromatic, and the colours are united, not precisely, at the lens Cg , but about $\frac{1}{10}$ th of an inch nearer the eye-glass.

It is obvious that this combination of glasses may be used as a microscope; for if, instead of the image formed by the object-glass at FG , we substitute a small object, illuminated from behind, as in compound microscopes; and if we draw the eye-piece a very small way from this object, the pencils of parallel rays emergent from the eye-glass D will become convergent to very distant points, and will there form an inverted and enlarged picture of the object, which may be viewed by a Huyghenian eye-piece; and we may thus get high magnifying powers without using very deep glasses. We tried the eye-piece of which we have given the dimensions in this way, and found that it might be made to magnify 180 times with very great distinctness. When used as the magnifier of a solar microscope, it infinitely surpasses every thing we have ever seen. The picture formed by a solar microscope is generally so indistinct, that it is fit only for amusing ladies; but with this magnifier it seemed perfectly sharp. We therefore recommend this to the artists as a valuable article of their trade.

The only thing which remains to be considered in the theory

Telescope. theory of refracting telescopes is the forms of the different lenses. Hitherto we have had no occasion to consider any thing but their focal distances; but their aberrations depend greatly on the adjustment of their forms to their situations. When the conjugate focuses of a lens are determined by the service which it is to perform, there is a certain form or proportion between the curvatures of their anterior and posterior surfaces, which will make their aberrations the smallest possible.

It is evident that this proportion is to be obtained by making the fluxion of the quantity within the parenthesis in the formula of par. 2. col. 2. p. 348. equal to nothing. When this is done, we obtain this formula for a , the radius of curvature

for the anterior surface of a lens. $\frac{1}{a} = \frac{2m^2+m}{2m+4} + \frac{4m+4}{2(m+4)r}$, where m is the ratio of the sine of incidence to the sine of refraction, and r is the distance of the focus of incident rays, positive or negative, according as they converge or diverge, all measured on a scale of which the unit is n , = half of the radius of the equivalent isosceles lens.

It will be sufficiently exact for our purpose to suppose $m = \frac{3}{2}$, though it is more nearly $\frac{31}{20}$. In this case $\frac{1}{a} = \frac{1}{7} + \frac{10}{7r} = \frac{42r+70}{49r}$. Therefore $a = \frac{49r}{42r+70}$. And $\frac{1}{b} = \frac{1}{a} - \frac{1}{r} = \frac{1-a}{a}$.

As an example, let it be required to give the radii of curvature in inches for the eye-glass bc of page 362. col. 1. par. 2. which we shall suppose of $1\frac{1}{2}$ inches focal distance, and that ec ($=r$) is $3\frac{1}{4}$ inches.

The radius of curvature for the equivalent isosceles lens is 1,5, and its half is 0,75. Therefore $r = \frac{3\frac{1}{4}}{0,75} = 5$; and our formula is $a = \frac{49 \times 5}{42 \times 5 + 70} = \frac{245}{280} = 0,875$; and $\frac{1}{b} = \frac{1-a}{a} = \frac{0,125}{0,875}$, and $b = \frac{0,875}{0,125} = 7$.

These values are parts of a scale, of which the unit is 0,75 inches. Therefore

$$a, \text{ in inches, } = 0,875 \times 0,75, = 0,65525$$

$$b, \text{ in inches, } = 7 \times 0,75, = 5,25.$$

And here we must observe that the posterior surface is concave: for b is a positive quantity, because $1-a$ is a positive quantity as well as a ; therefore the centre of sphericity of both surfaces lies beyond the lens.

And this determination is not very different from the usual practice, which commonly makes this lens a plane convex with its flat side next the eye: and there will not be much difference in the performance of these two lenses; for in all cases of maxima and minima, even a pretty considerable change of the best dimensions does not make a sensible change in the result.

The same consideration leads to a rule which is very simple, and sufficiently exact for ordinary situations. This is to make the curvatures such, that the incident and emergent pencils may be nearly equally inclined to the surfaces of the lens. Thus in the eye-piece with five glasses, A and B should be most convex on their anterior sides; C should be most convex on the posterior side; D should be nearly isosceles; and E nearly plano-convex.

But this is not so easy a matter as appears at first sight. The lenses of an eye-piece have not only to bend the several pencils of light to and from the axis of the telescope; they have also to form images on the axes of these pencils. These offices frequently require opposite forms, as mentioned in par.

3. col. 2. p. 360. Thus the glass A of fig. 20. n^o 2. should be most convex on the side next the object, that it may produce little distortion of the pencils. But it should be most convex next the eye, that it may produce distinct vision of the image FG, which is very near it. This image should have its concavity turned towards A, whereas it is towards the object-glass. We must therefore endeavour to make the vertical image fg flatter, or even convex. This requires a glass very flat before and convex behind. For similar reasons the object-glass of a microscope and the simple eye-glass of an astronomical telescope should be formed the same way.

This is a subject of most difficult discussion, and requires a theory which few of our readers would relish; nor does our limits afford room for it. The artists are obliged to grope their way. The proper method of experiment would be, to make eye-pieces of large dimensions, with extravagant apertures to increase the aberrations, and to provide for each station A, B, C, and D, a number of lenses of the same focal distance, but of different forms: and we would advise making the trial in the way of a solar microscope, and to have two eye-pieces on trial at once. Their pictures can be formed on the same screen, and accurately compared; whereas it is difficult to keep in remembrance the performance of one eye-piece, and compare it with another.

We have now treated the theory of refracting telescopes with considerable minuteness, and have perhaps exceeded the limits which some readers may think reasonable. But we have long regretted that there is not any theory on this subject from which a curious person can learn the improvements which have been made since the time of Dr Smith, or an artist learn how to proceed with intelligence in his profession. If we have accomplished either of these ends, we trust that the public will receive our labours with satisfaction.

We cannot add any thing to what Dr Smith has delivered on the theory of reflecting telescopes. There appears to be the same possibility of correcting the aberration of the great speculum by the contrary aberration of a convex small speculum, that we have practised in the compound object-glass of an achromatic refracting telescope. But this cannot be, unless we make the radius of the convex speculum exceedingly large, which destroys the magnifying power and the brightness. This therefore must be given up. Indeed their performance, when well executed, does already surpass all imagination. Dr Herschel has found great advantages in what he calls the *front view*, not using a plane mirror to throw the pencils to one side. But this cannot be practised in any but telescopes so large, that the loss of light, occasioned by the interposition of the observer's head, may be disregarded.

Nothing remains but to describe the mechanism of some of the most convenient forms.

To describe all the varieties of shape and accommodation which may be given to a telescope, would be a task as trifling as prolix. The artists of London and of Paris have racked their inventions to please every fancy, and to suit every purpose. We shall content ourselves with a few general maxims, deduced from the scientific consideration of a telescope, as an instrument by which the visual angle subtended by a distinct object is greatly magnified.

The chief consideration is to have a steady view of the distant object. This is unattainable, unless the axis of the instrument be kept constantly directed to the same point of it: for when the telescope is gently shifted from its position, the object seems to move in the same or in the opposite direction, according as the telescope inverts the object or shows

Telescope. shows it erect. This is owing to the magnifying power, because the apparent angular motion is greater than what we naturally connect with the motion of the telescope. This does not happen when we look through a tube without glasses.

All shaking of the instrument therefore makes the object dance before the eye; and this is disagreeable, and hinders us from seeing it distinctly. But a tremulous motion, however small, is infinitely more prejudicial to the performance of a telescope, by making the object quiver before us. A person walking in the room prevents us from seeing distinctly; nay, the very pulsation in the body of the observer, agitates the floor enough to produce this effect, when the telescope has a great magnifying power: For the visible motion of the object is then an imperceptible tremor, like that of an harpsichord wire, which produces an effect precisely similar to optical indistinctness; and every point of the object is diffused over the whole space of the angular tremor, and appears coexistent in every part of this space, just as a harpsichord wire does while it is sounding. The more rapid this motion is, the indistinctness is the more complete. Therefore the more firm and elastic and well bound together the frame-work and apertures of our telescope is, the more hurtful will this consequence be. A mounting of lead, were it practicable, would be preferable to wood, iron, or brass. This is one great cause of the indistinctness of the very finest reflecting telescopes of the usual constructions, and can never be totally removed. In the Gregorian form, it is hardly possible to damp the elastic tremor of the small speculum, carried by an arm supported at one end only, even though the tube were motionless. We were witnesses of a great improvement made on a four-feet reflecting telescope, by supporting the small speculum by a strong plate of lead placed across the tube, and led by an adjusting screw at each end. But even the great mirror may vibrate enough to produce indistinctness. Refracting telescopes are free from this inconvenience, because a small angular motion of the object-glass round one of its own diameters has no sensible effect on the image in its focus. They are affected only by an angular motion of the axis of the telescope or of the eye-glasses.

This single consideration gives us great help towards judging of the merits of any particular apparatus. We should study it in this particular, and see whether its form makes the tube readily susceptible of such tremulous motions. If it does, the firmer it is and the more elastic it is, the worse. All forms therefore where the tube is supported only near the middle, or where the whole immediately or remotely depend on one narrow joint, are defective.

Reasoning in this way, we say with confidence, that of all the forms of a telescope apparatus, the old fashioned simple stand represented in fig. 21. is by far the best, and that others are superior according as the disposition of the points of support of the tube approaches to this. Let the pivots A, B, be fixed in the lintel and sole of a window. Let the four braces terminate very near to these pivots. Let the telescope lie on the pin F, resting on the shoulder round the eye-piece, while the far end of it rests on one of the pins 1, 2, 3, &c.; and let the distance of these pins from F very little exceed the length of the telescope. The trembling of the axis, even when considerable, cannot affect the position of the tube, because the braces terminate almost at the pivots. The tremor of the brace CD does as little harm, because it is nearly perpendicular to the tube. And if the object glass were close at the upper supporting pin, and the focus at the lower pin F, even the bending and trembling of the tube will have no effect on its optical axis. The instrument is only subject to horizontal tremors. These

may be almost annihilated by having a slender rod coming from a hook's joint in the side of the window, and passing through such another joint close by the pin F. We have seen an instrument of this form, having AB parallel to the earth's axis. The whole apparatus did not cost 50 shillings, and we find it not in the least sensible manner affected by a storm of wind. It was by observations with this instrument that the tables of the motions of the Georgium Sidus, published in the Edinburgh Transactions, were constructed, and they are as accurate as any that have yet appeared. This is an excellent equatorial.

But this apparatus is not portable, and it is sadly deficient in elegance. The following is the best method we have seen of combining these circumstances with the indispensable requisites of a good telescope.

The pillar VX (fig. 22.) rises from a firm stand, and has a horizontal motion round a cone which completely fills it. This motion is regulated by a rack-work in the box at V. The screw of this rack-work is turned by means of the handle P, of a convenient length, and the screw may be disengaged by the click or detent V, when we would turn the instrument a great way at once. The telescope has a vertical motion round the joint Q placed near the middle of the tube. The lower end of the tube is supported by the stay OT. This consists of a tube RT, fastened to the pillar by a joint T, which allows the stay to move in a vertical plane. Within this tube slides another, with a stiff motion. This tube is connected with the telescope by another joint O, also admitting motion in a vertical plane. The side M of this inner tube is formed into a rack, in which works a pinion fixed to the top of the tube RT, and turned by the flat finger-piece R. The reader will readily see the advantages and the remaining defects of this apparatus. It is very portable, because the telescope is easily disengaged from it, and the legs and stay fold up. If the joint Q were immediately under A, it would be much freer from all tremor in the vertical plane. But nothing can hinder other tremors arising from the long pillar and the three springy legs. These communicate all external agitations with great vigour. The instrument should be set on a stone pedestal, or, what is better, a cask filled with wet sand. This pedestal, which necessity perhaps suggested to our scientific navigators, is the best that can be imagined.

Fig. 23 is the stand usually given to reflecting telescopes. The vertical tube FBG is fastened to the tube by finger screws, which pass through the slits at F and G. This arch turns round a joint in the head of the divided pillar, and has its edge cut into an oblique rack, which is acted on by the horizontal screw, furnished with the finger-piece A. This screw turns in a horizontal square frame. This frame turns round a horizontal joint in the off side, which cannot be seen in this view. In the side of this frame next the eye there is a finger-screw a, which passes through the frame, and presses on the round horizontal plate D. By screwing down this finger-screw, the frame is brought up, and presses the horizontal screw to the rack. Thus the elevation of the telescope is fixed, and may be nicely changed by the finger applied to A and turning this screw. The horizontal round plate D moves stiffly round on another plate of nearly equal diameter. This under plate has a deep conical hollow socket, which is nicely fitted by grinding to a solid cone formed on the top of the great upright pillar, and they may be firmly fixed in any position by the finger-screw E. To the under plate is fastened a box c, containing a horizontal screw C, which always works in a rack cut in the edge of the upper plate, and cannot be disengaged from it. When a great vertical or horizontal motion is wanted, the screws a and E are slacked, and by tightening them the telescope may be fixed.

TELEGRAPH.

Fig. 2.

Plate DII.

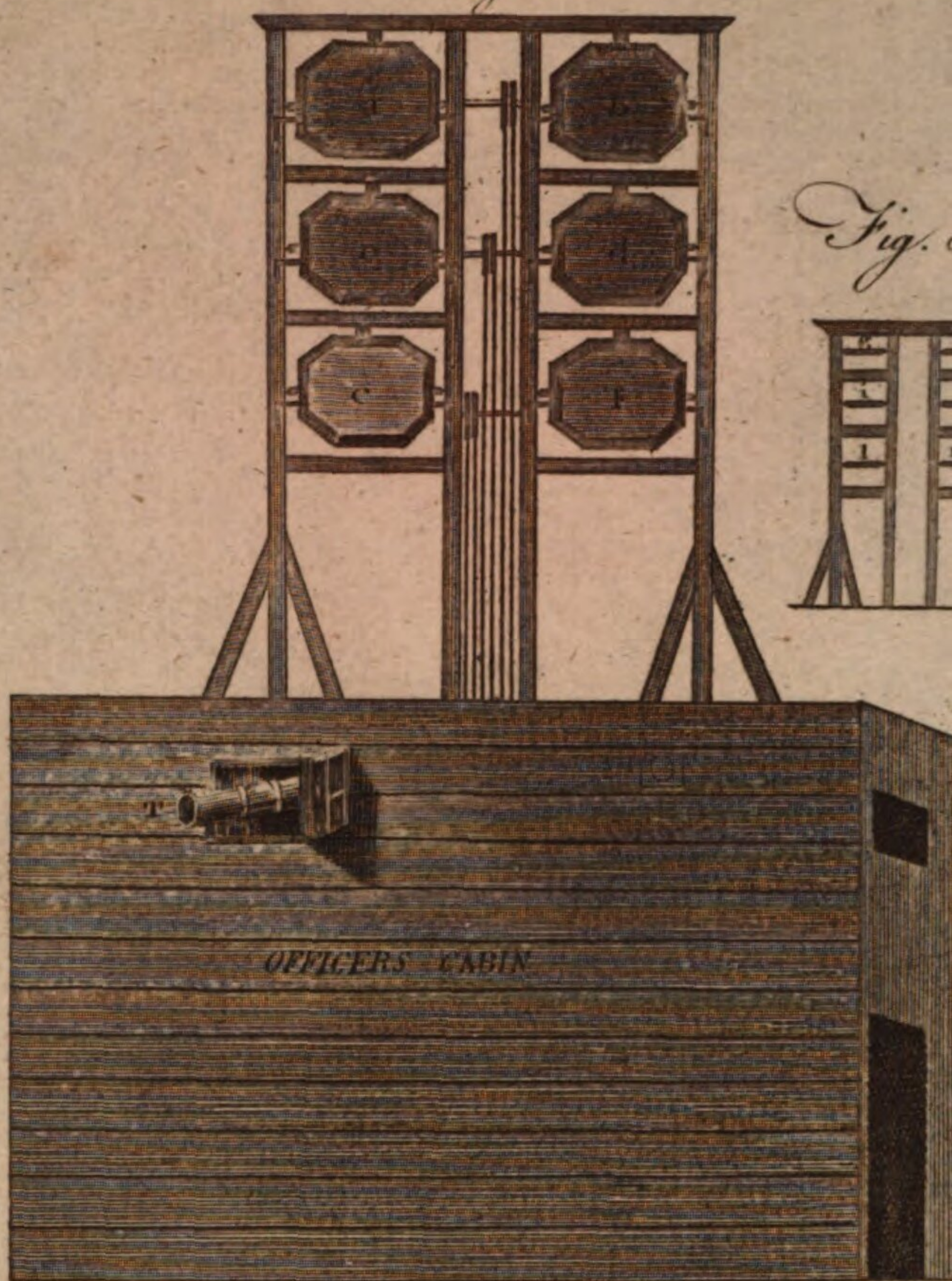
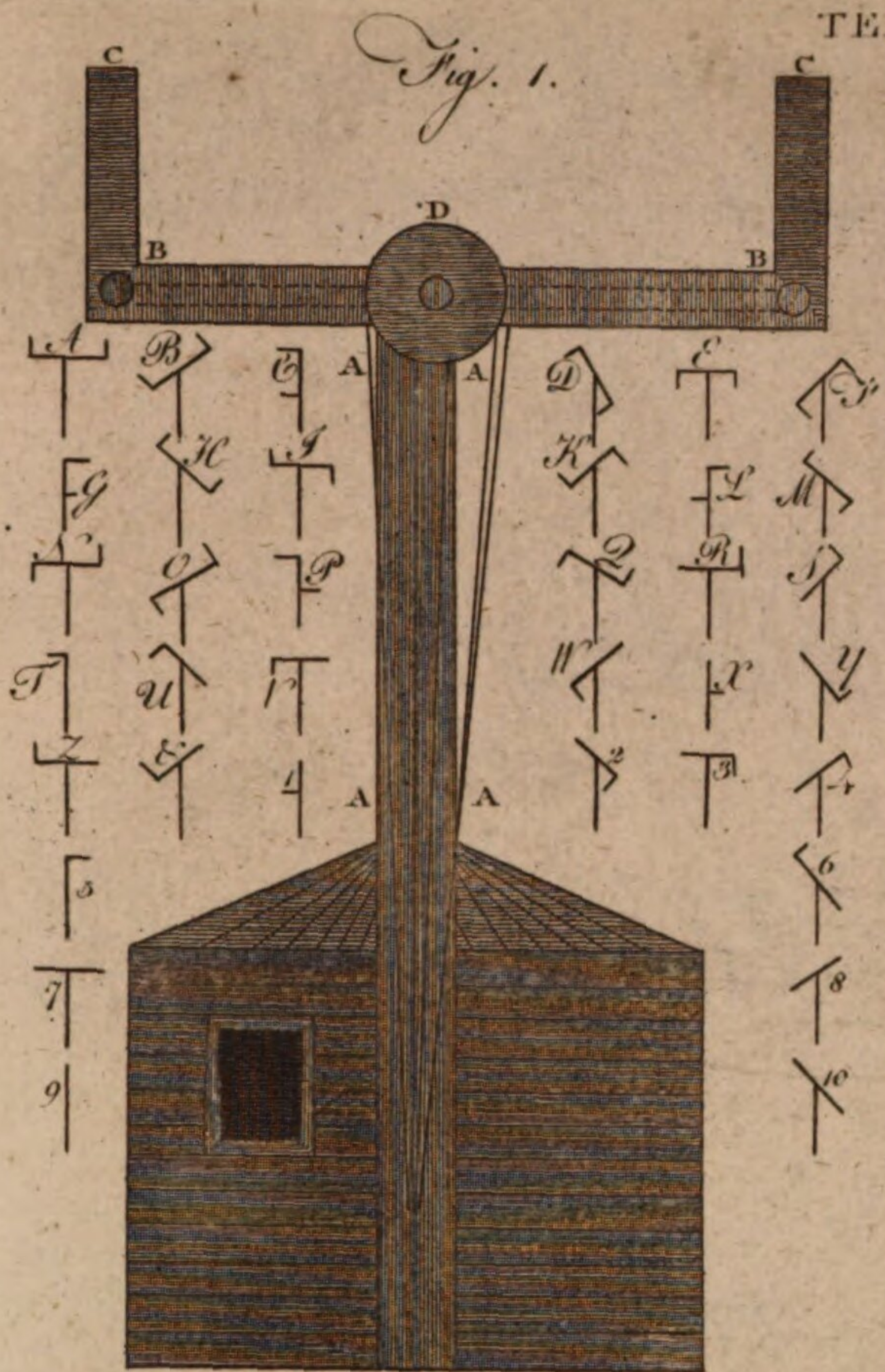


Fig. 3.

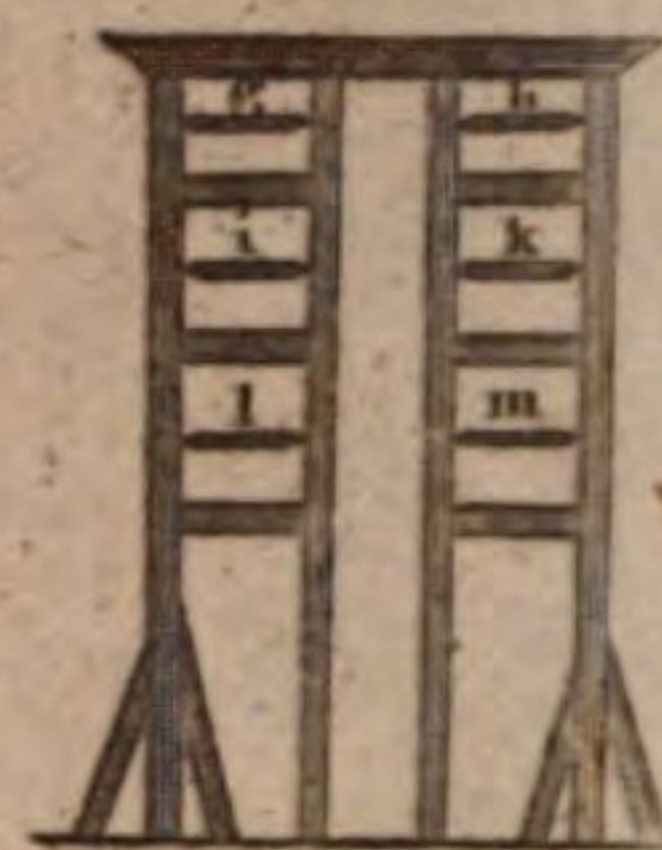
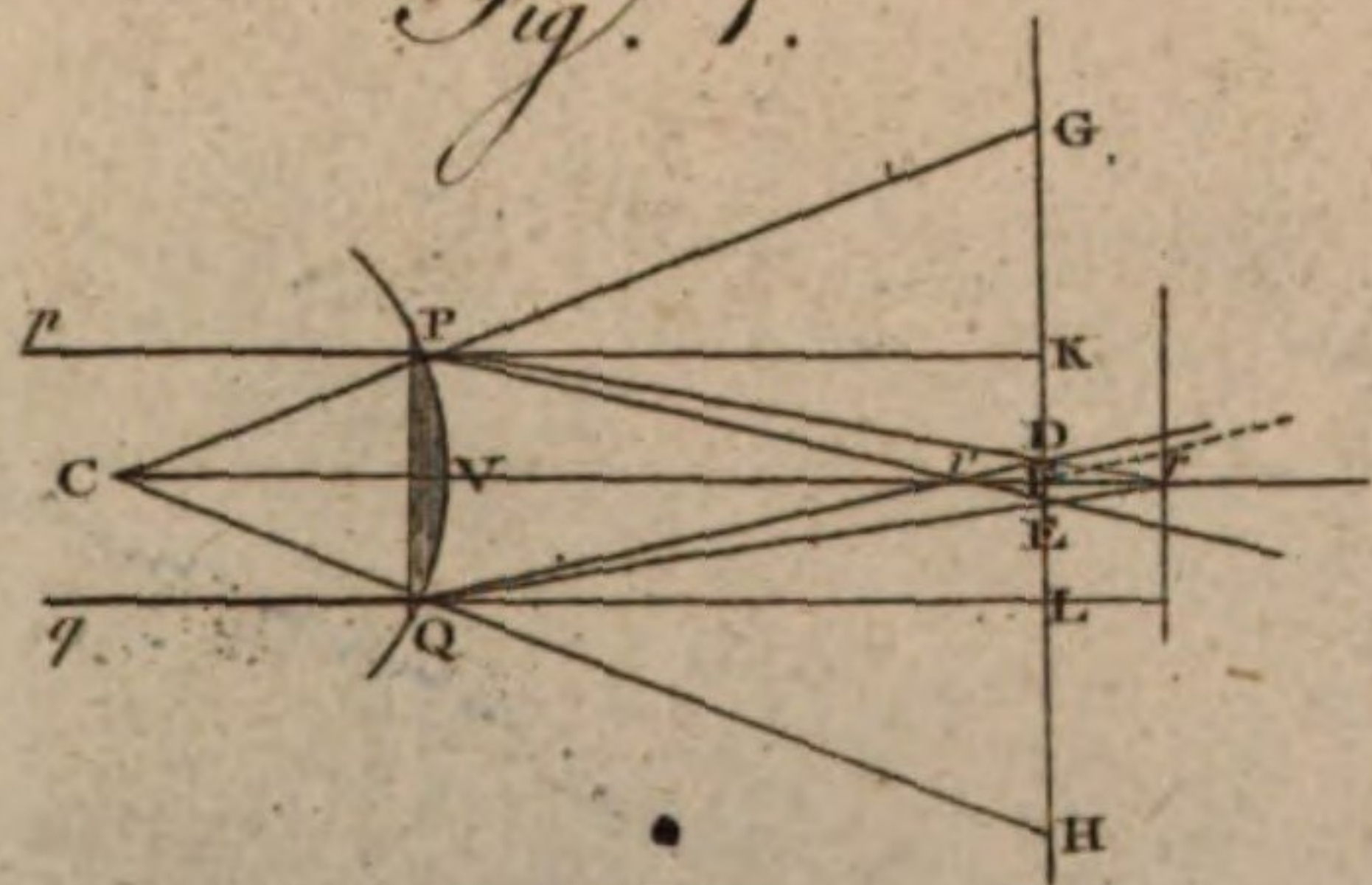


Fig. 1.



TELESCOPE.

Fig. 3.

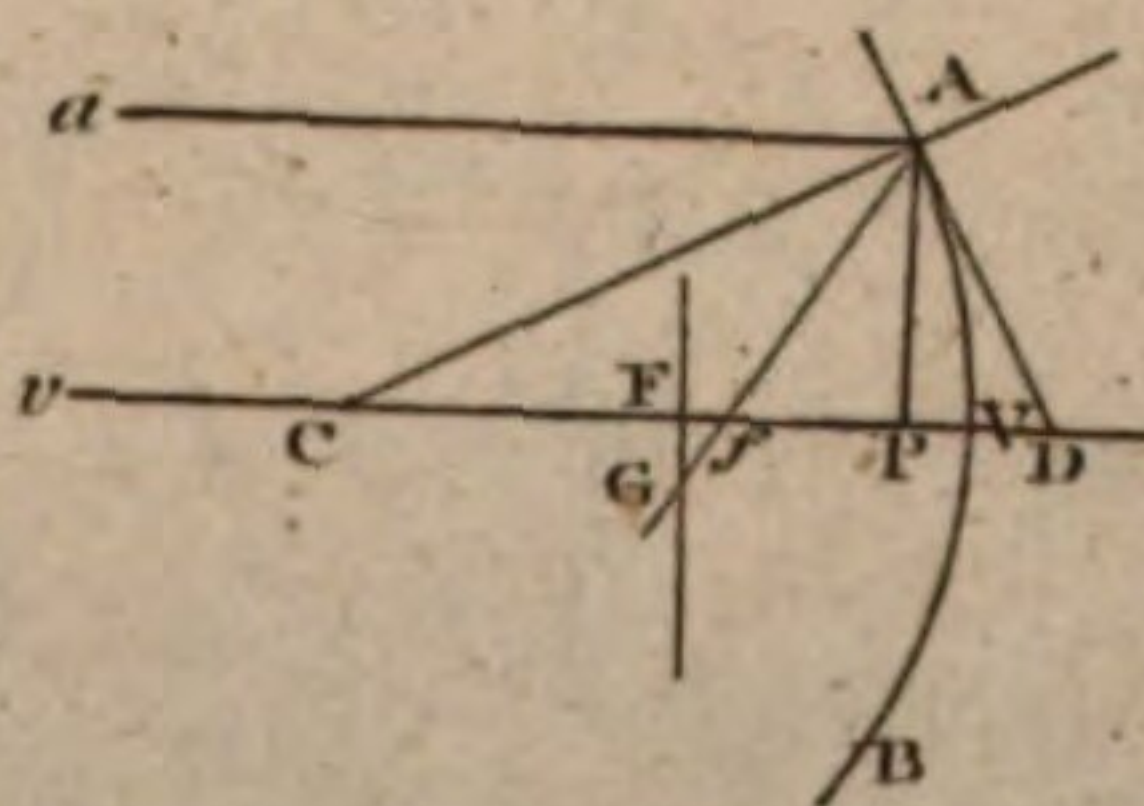


Fig. 4. A

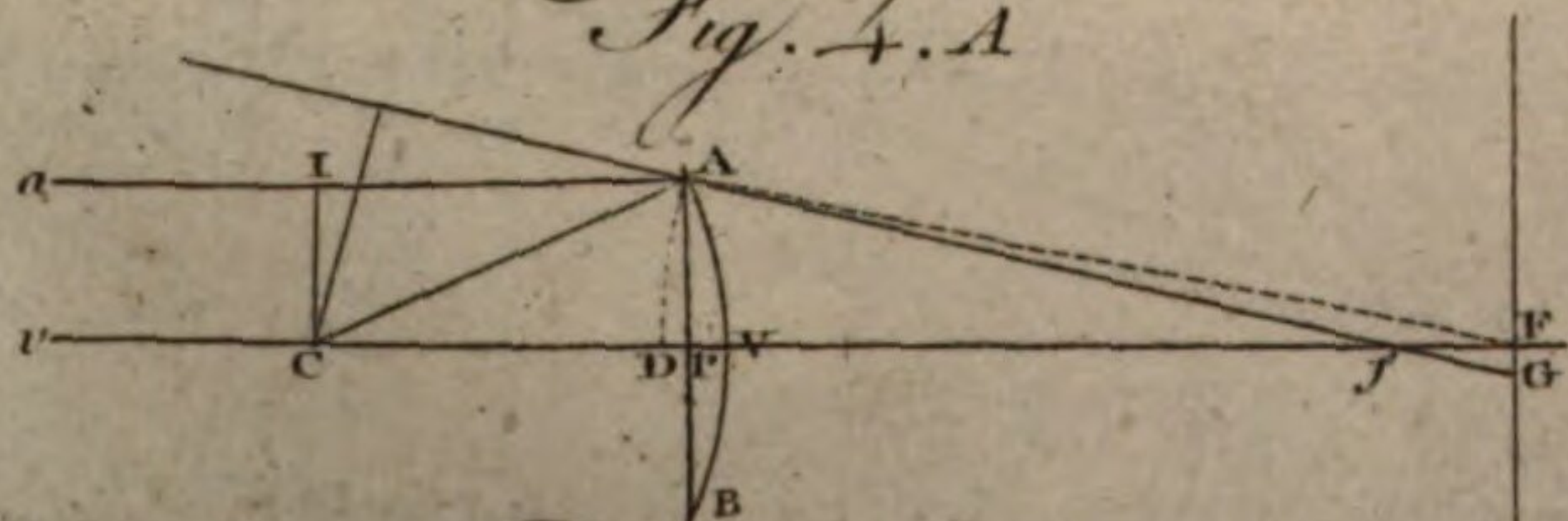


Fig. 4. B

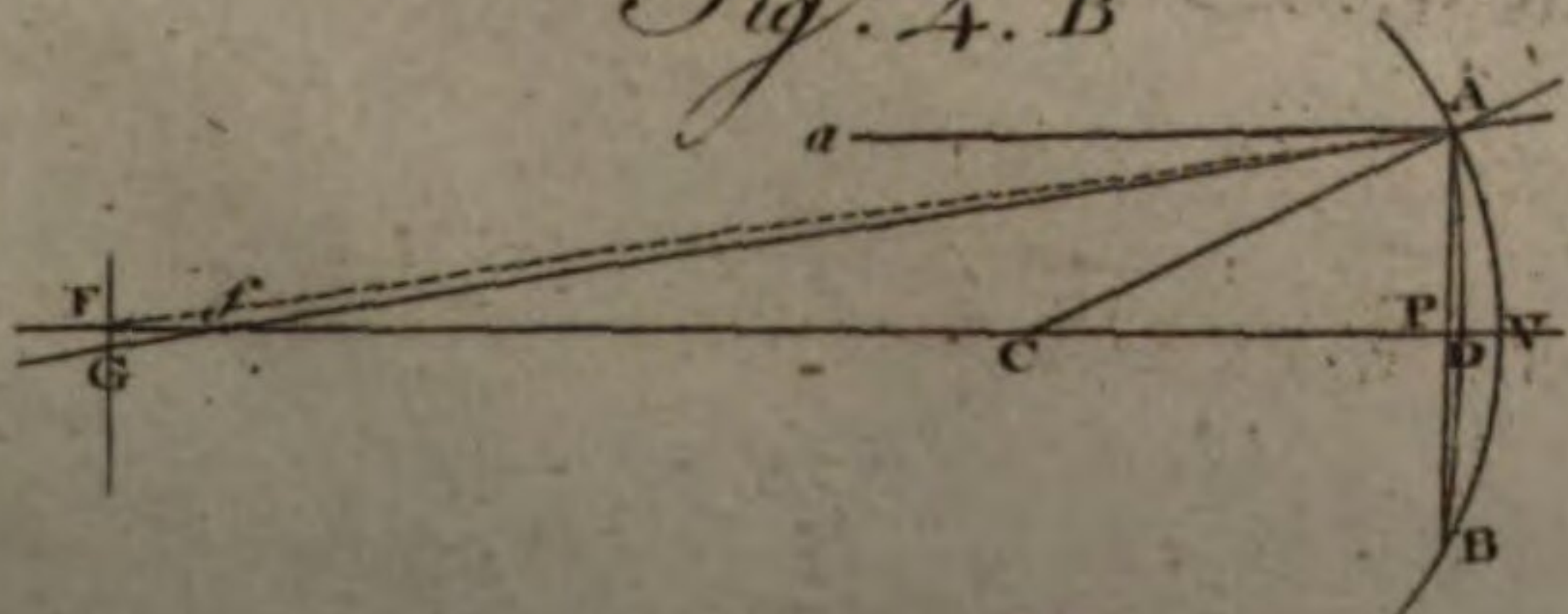


Fig. 2.

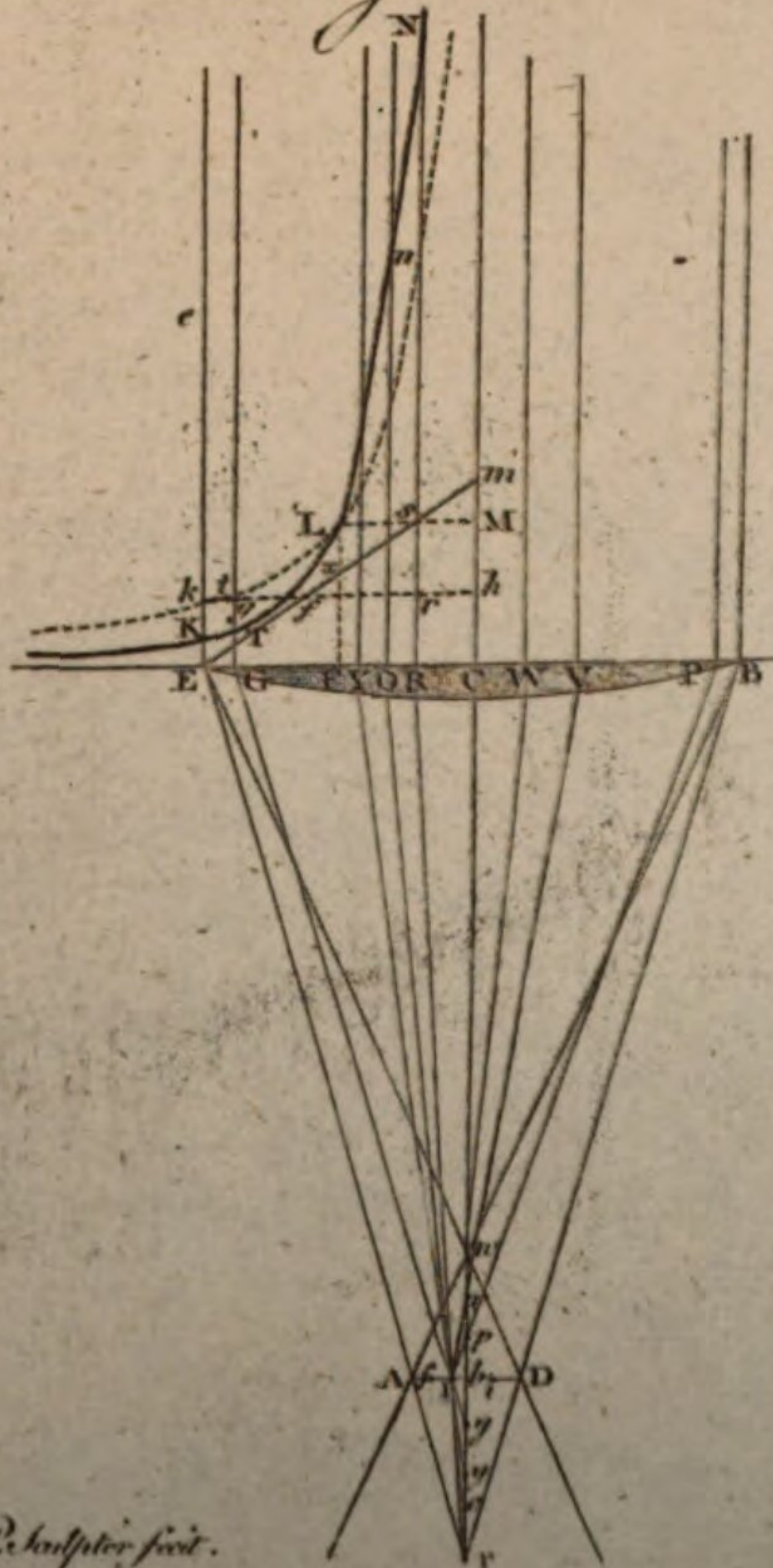


Fig. 5.B

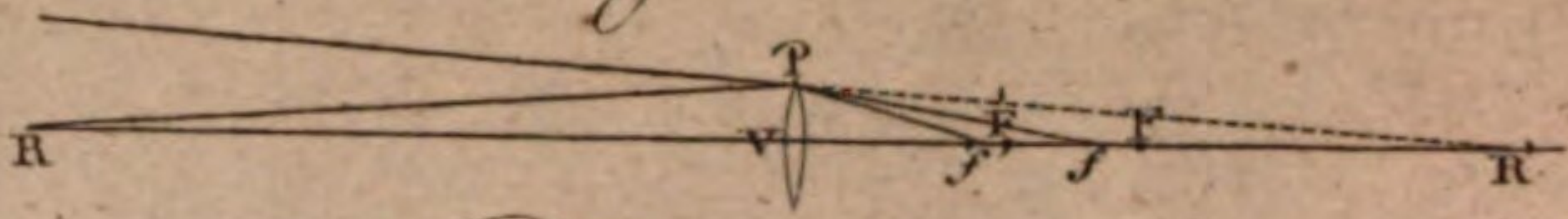


Fig. 5.C

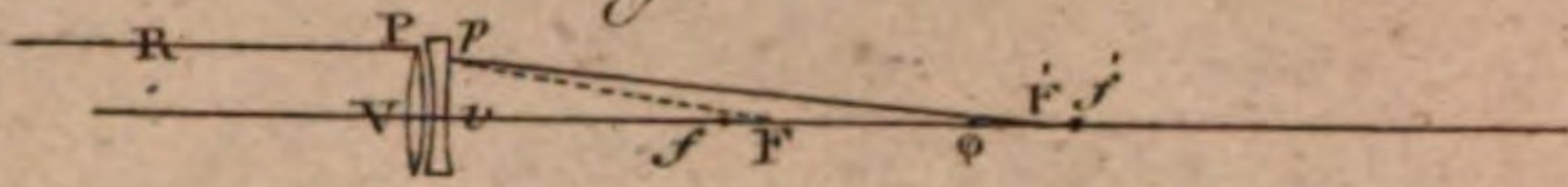


Fig. 5.

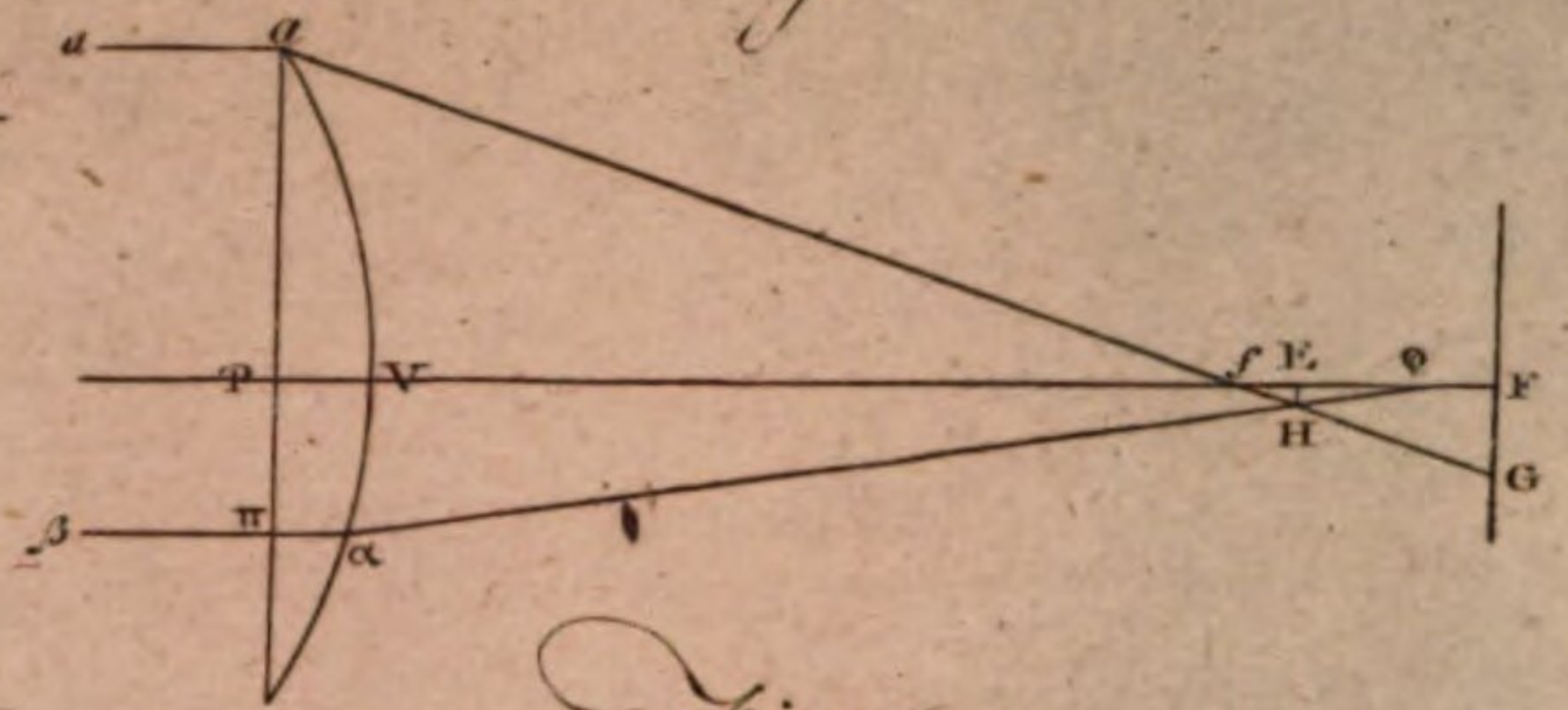


Fig. 7.

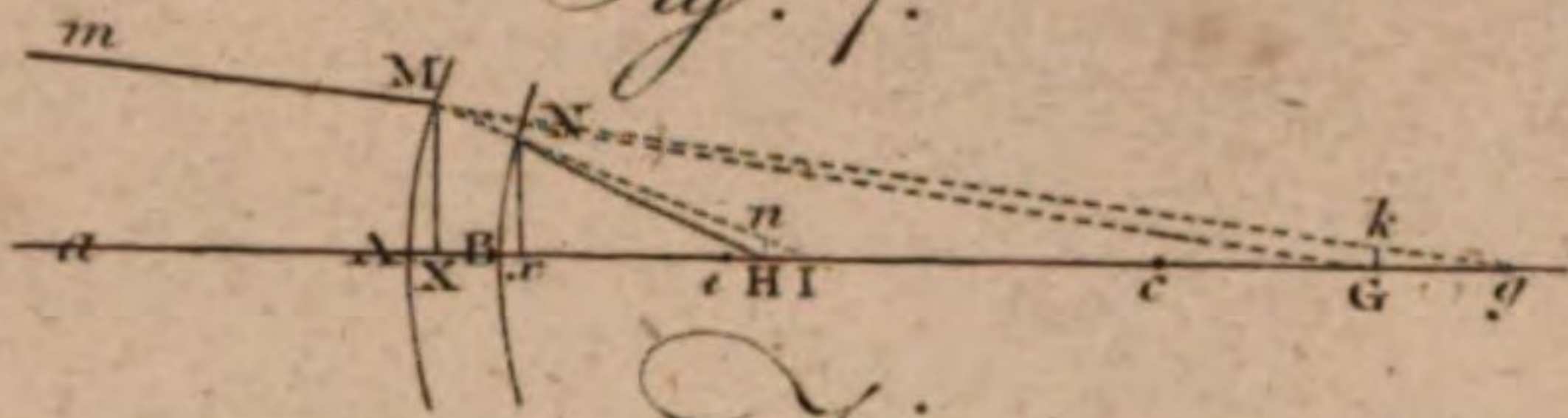


Fig. 8.

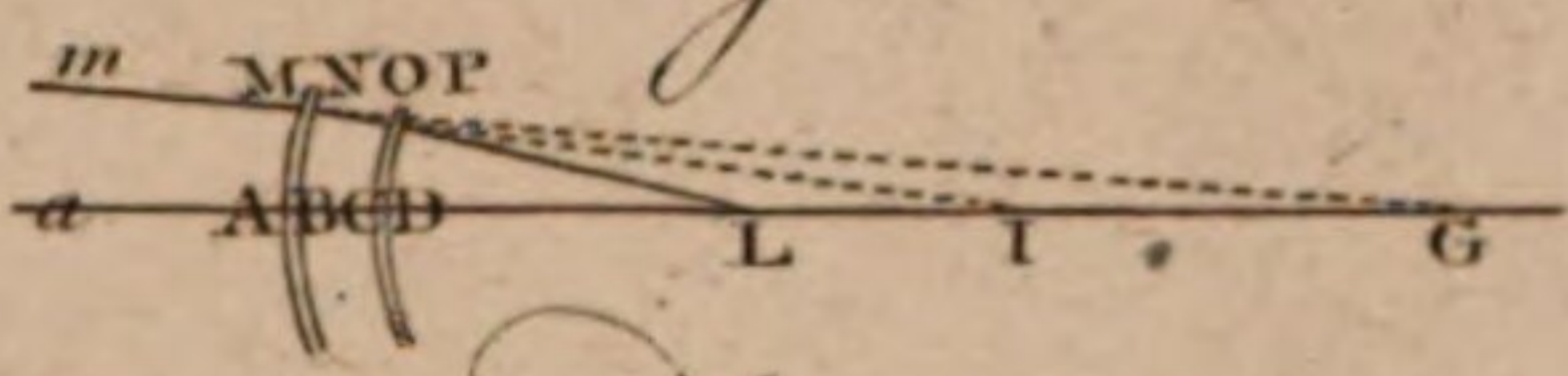


Fig. 10.B

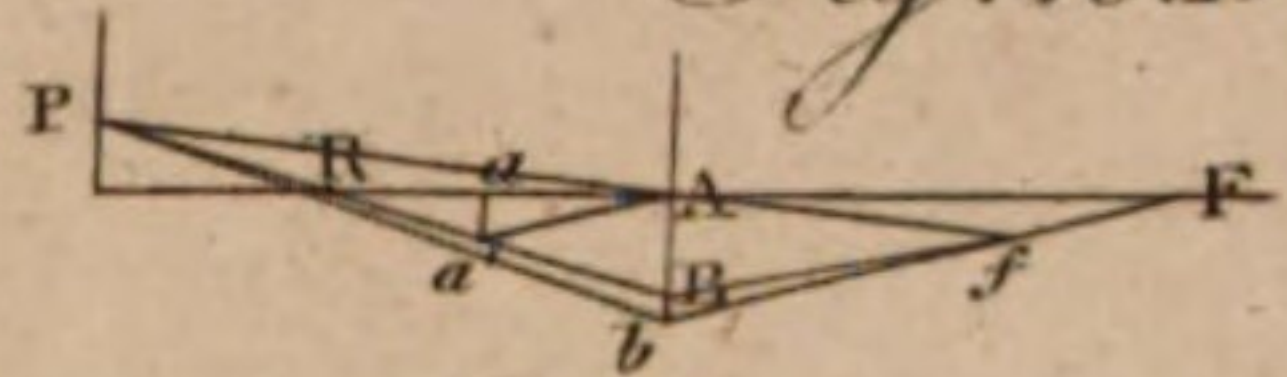


Fig. 10.

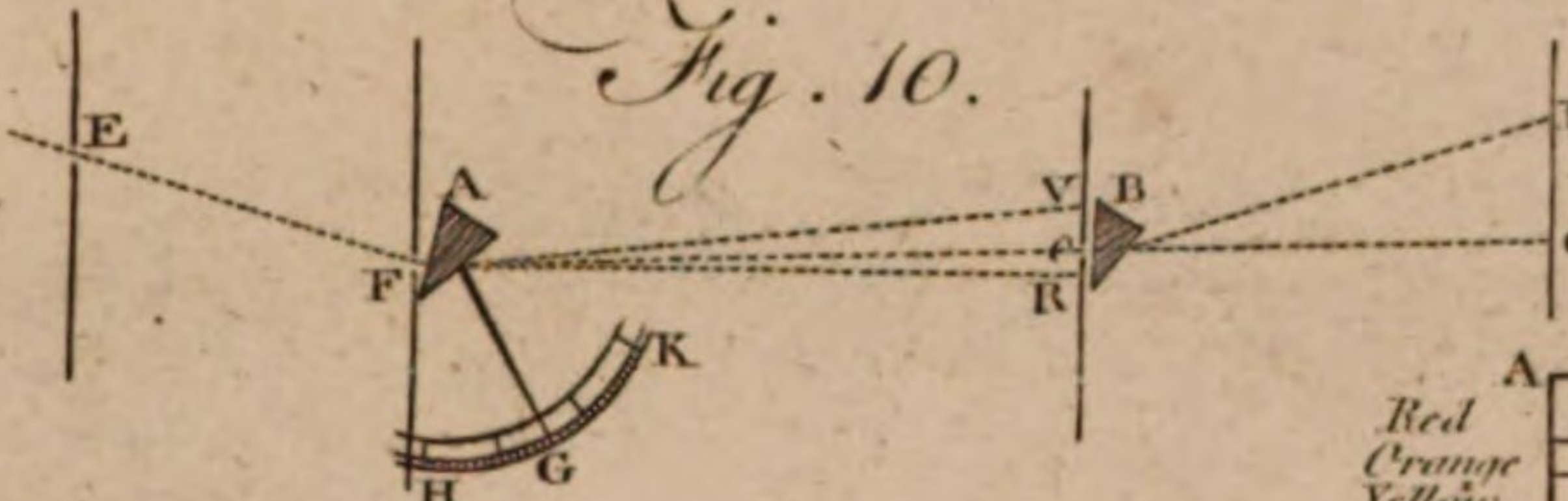


Fig. 6.

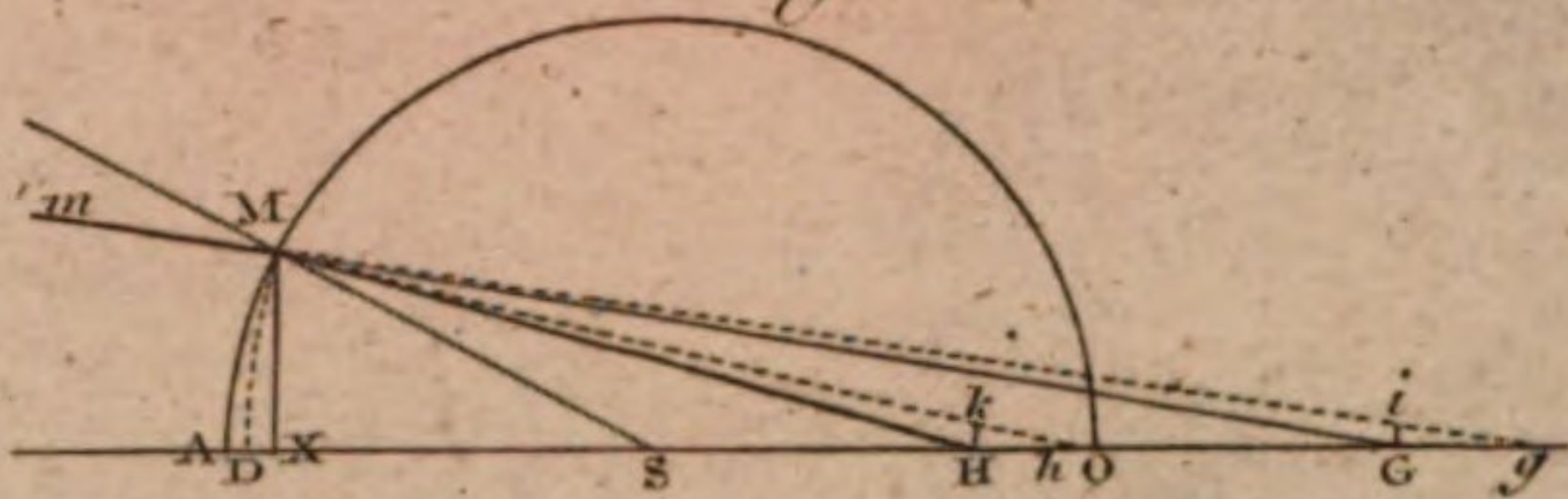


Fig. 9.A

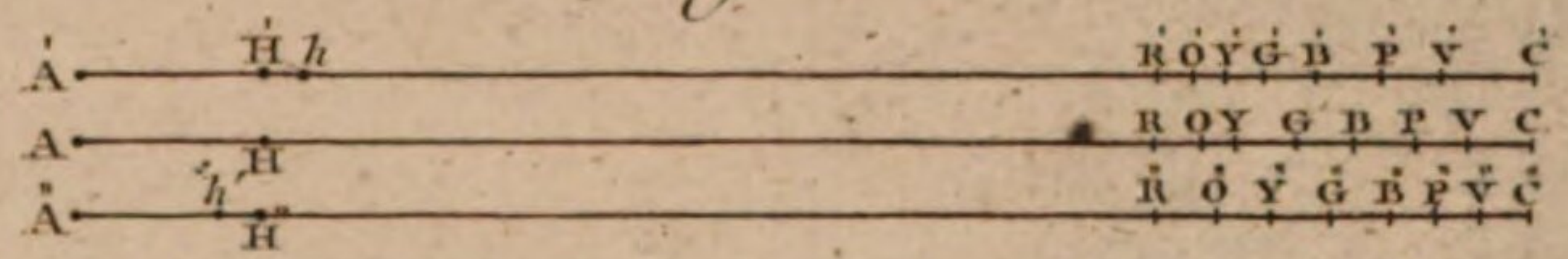


Fig. 9.B

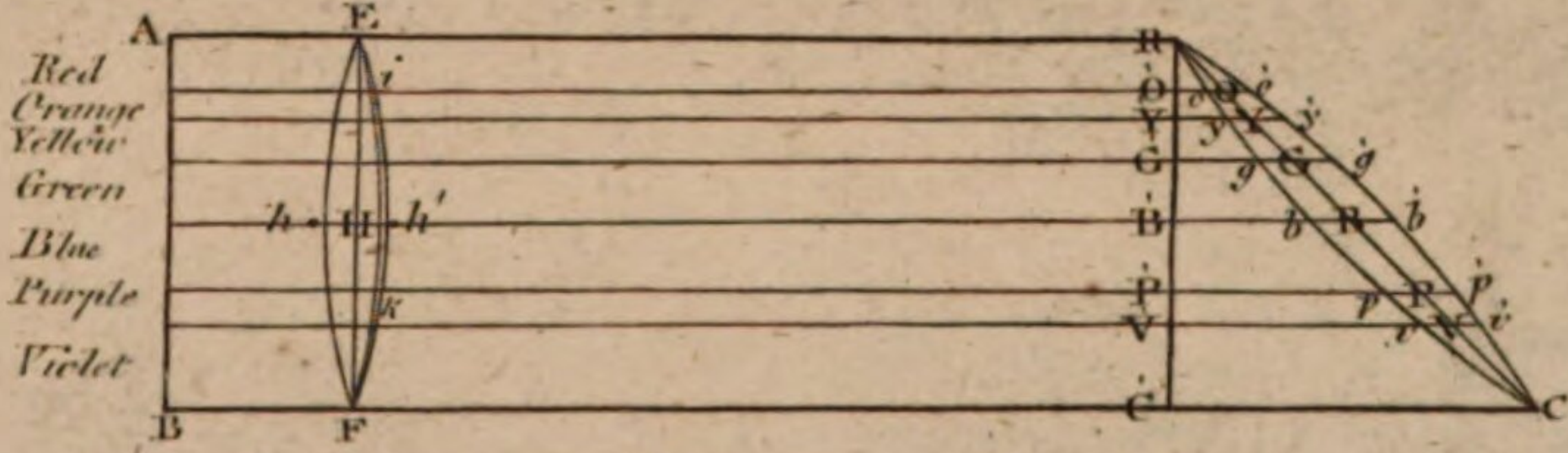


Fig. 13.

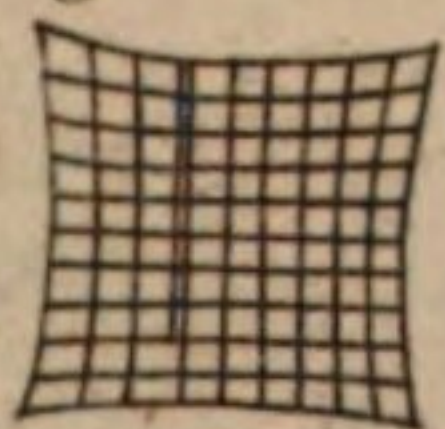


Fig. 12.

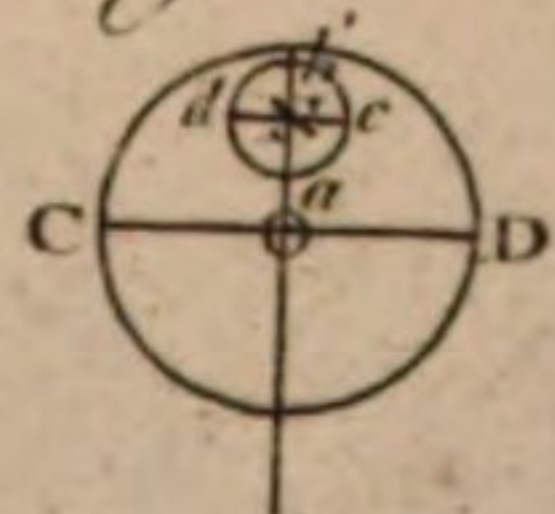


Fig. 15.A

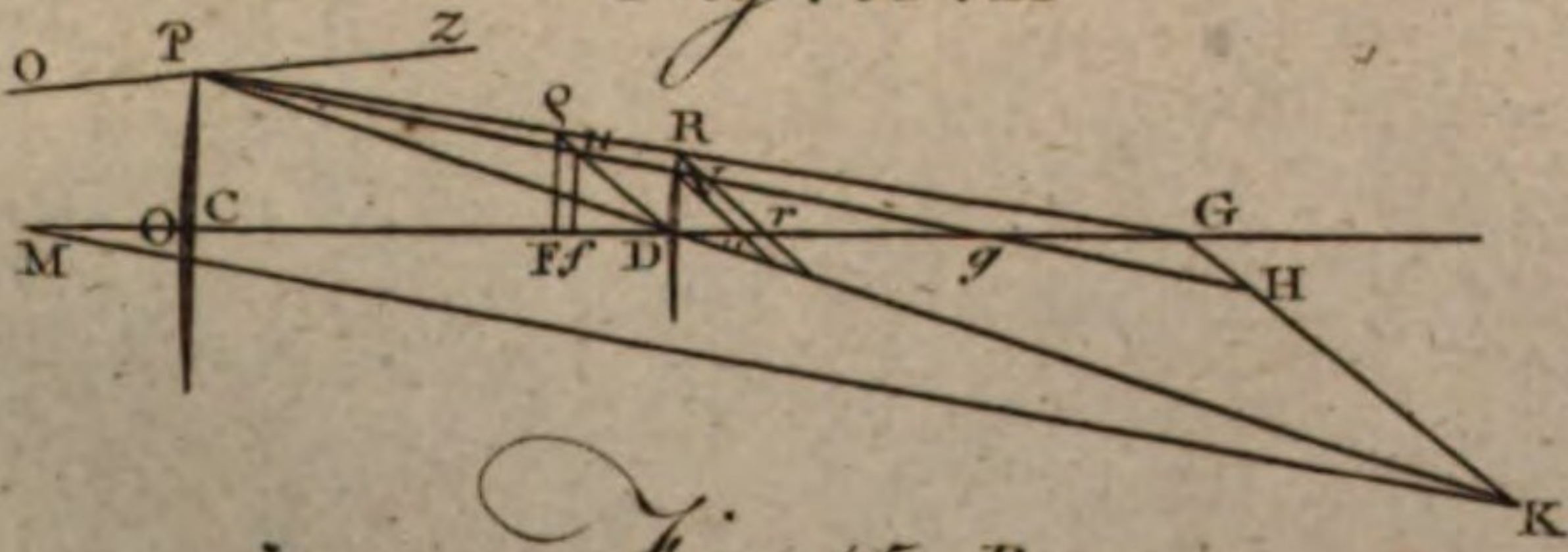


Fig. 15.B

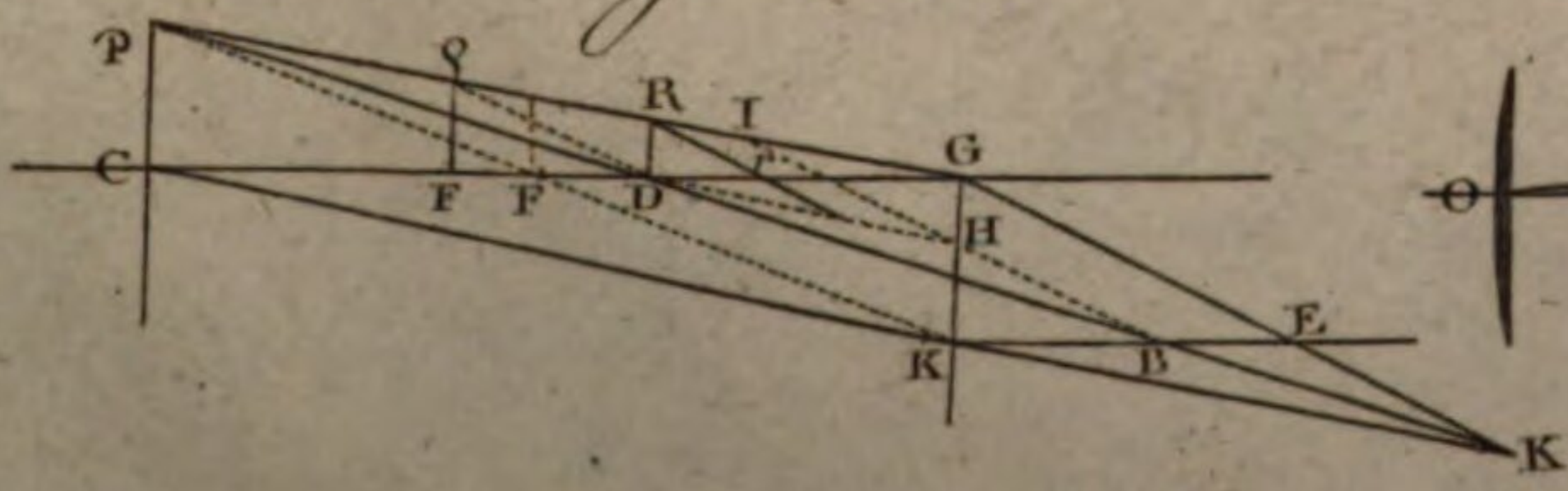


Fig. 11.



Fig. 14.A

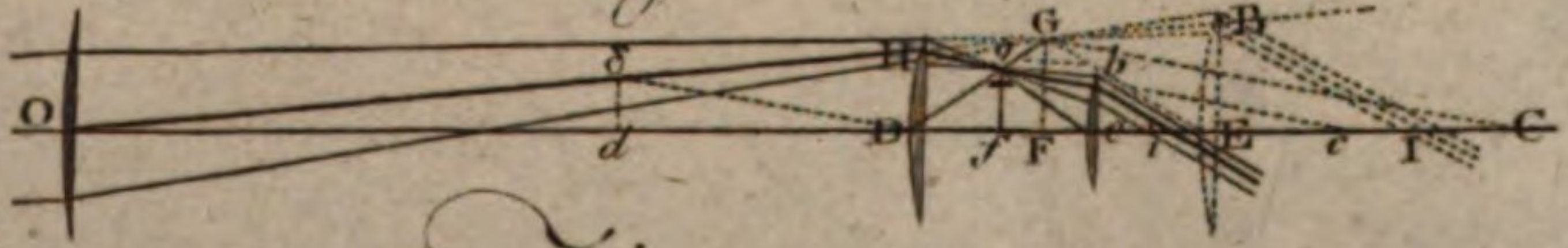


Fig. 14.B

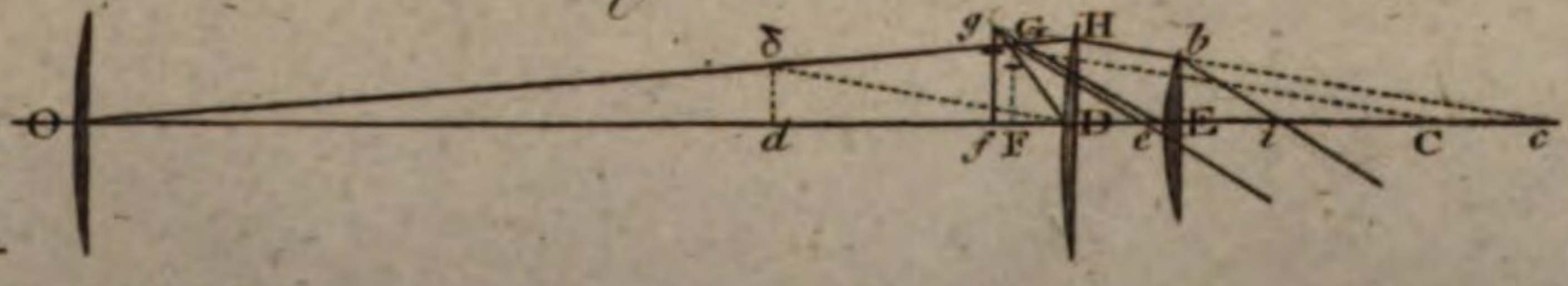


Fig. 16.



Fig. 17.

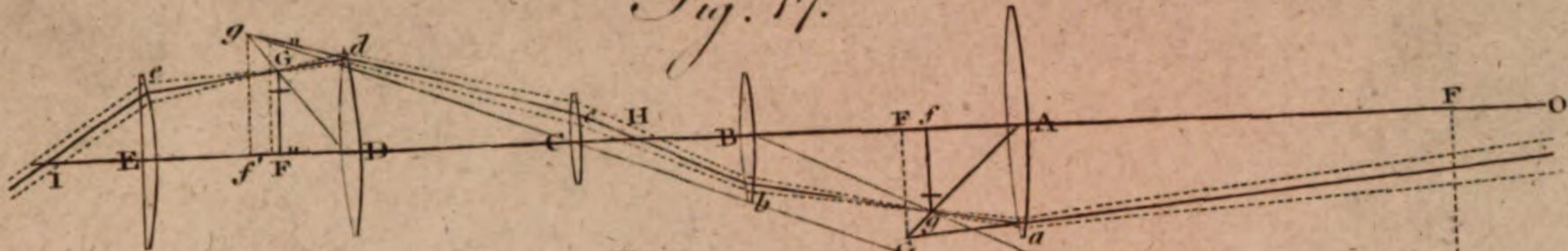


Fig. 18.

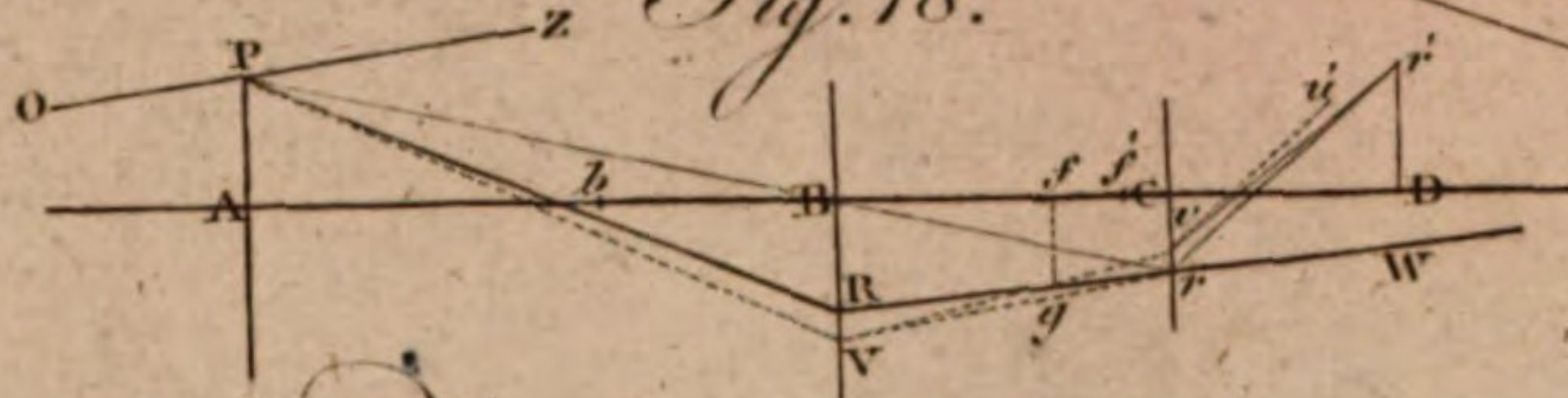


Fig. 19.

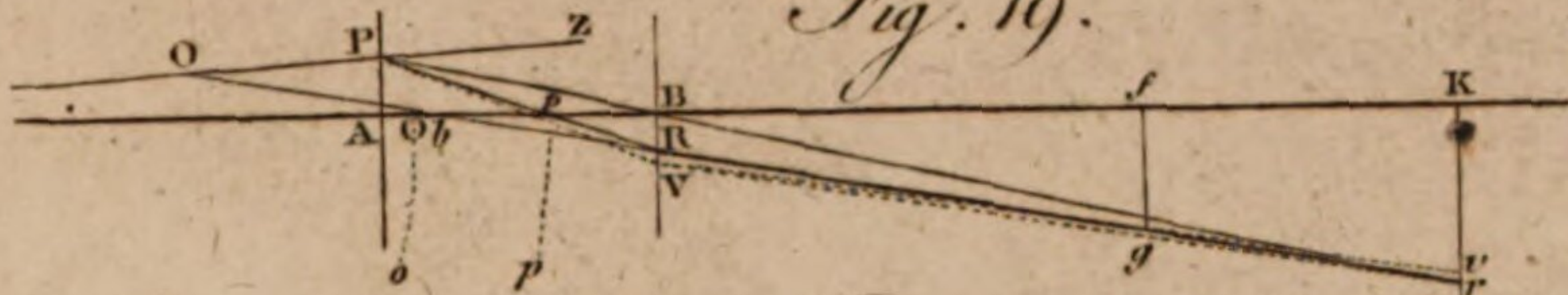


Fig. 20. N^o 2.

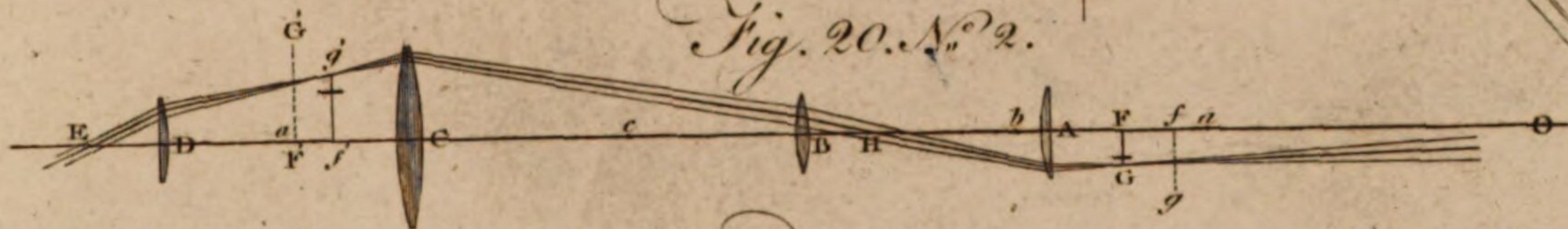


Fig. 20. N^o 1.

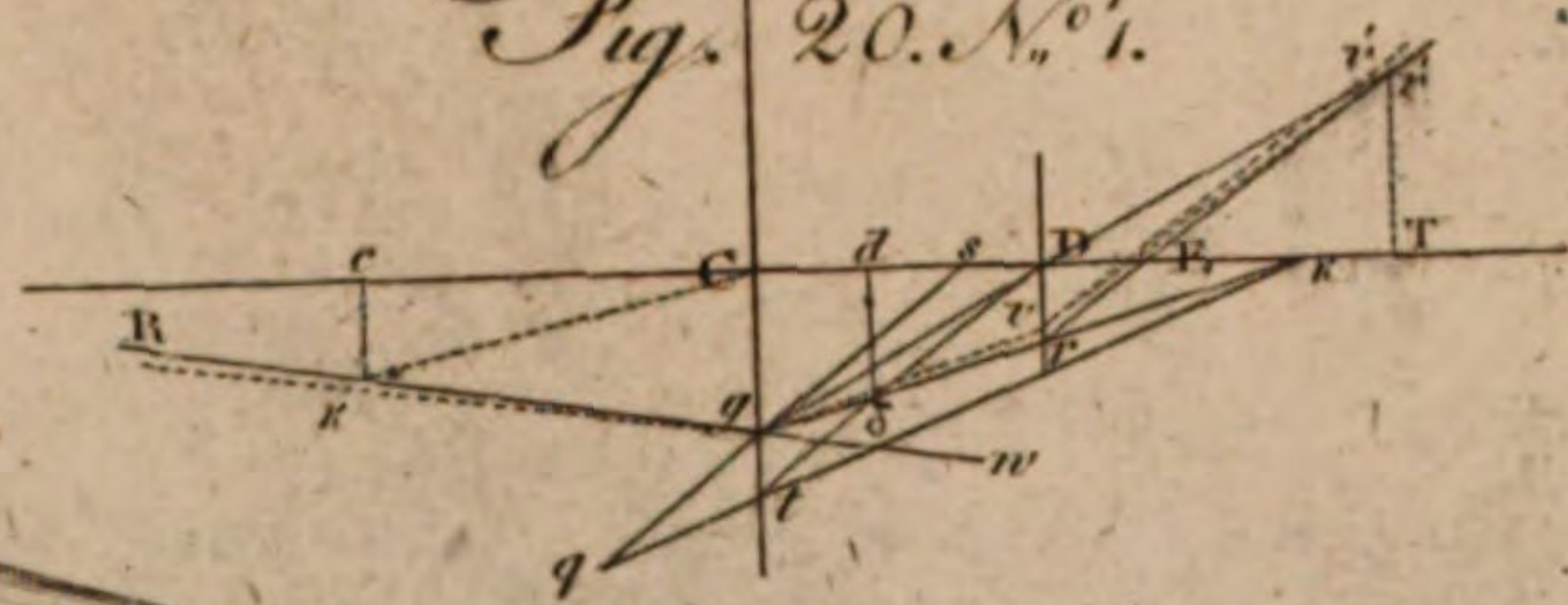


Fig. 21.

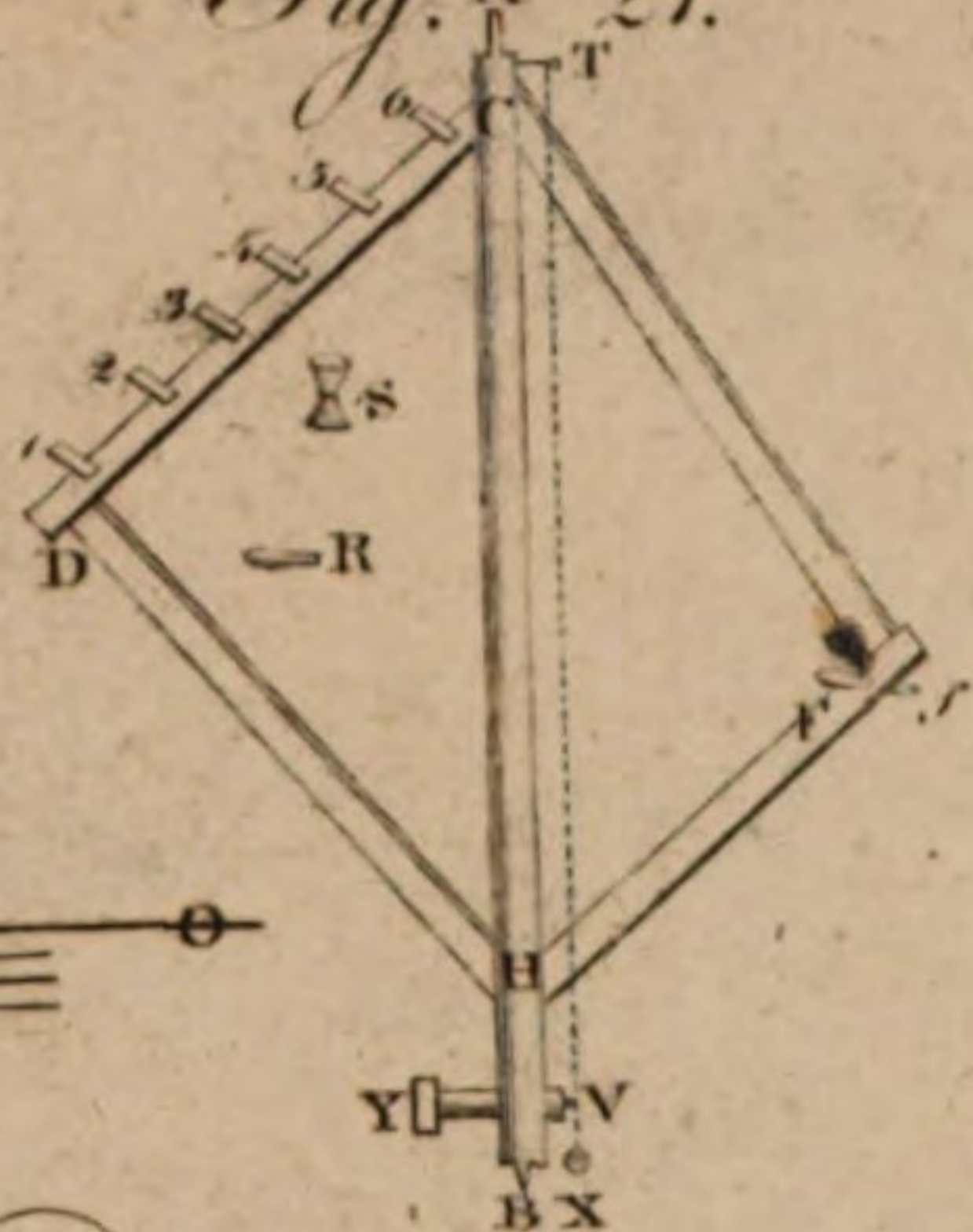


Fig. 23.

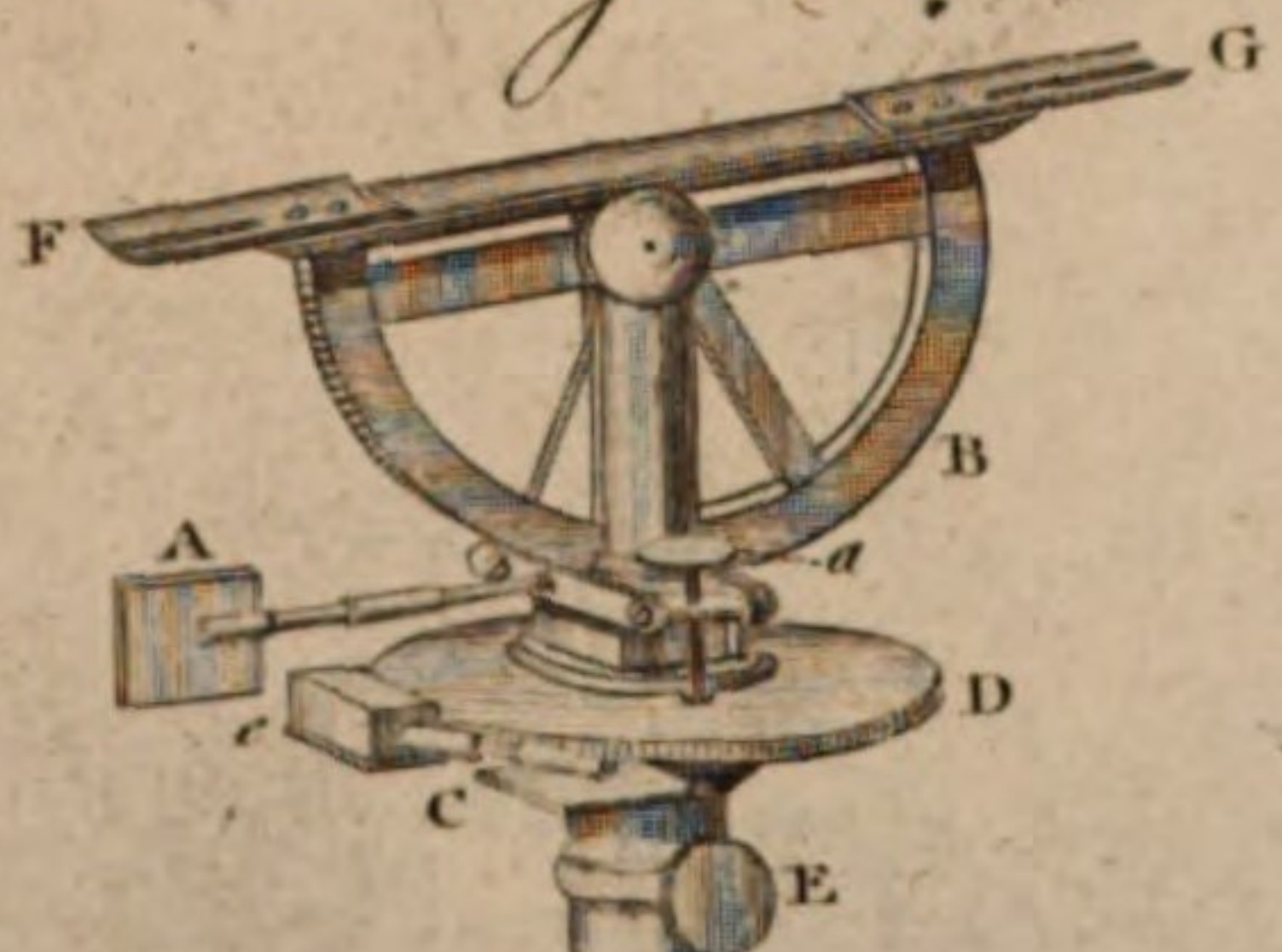
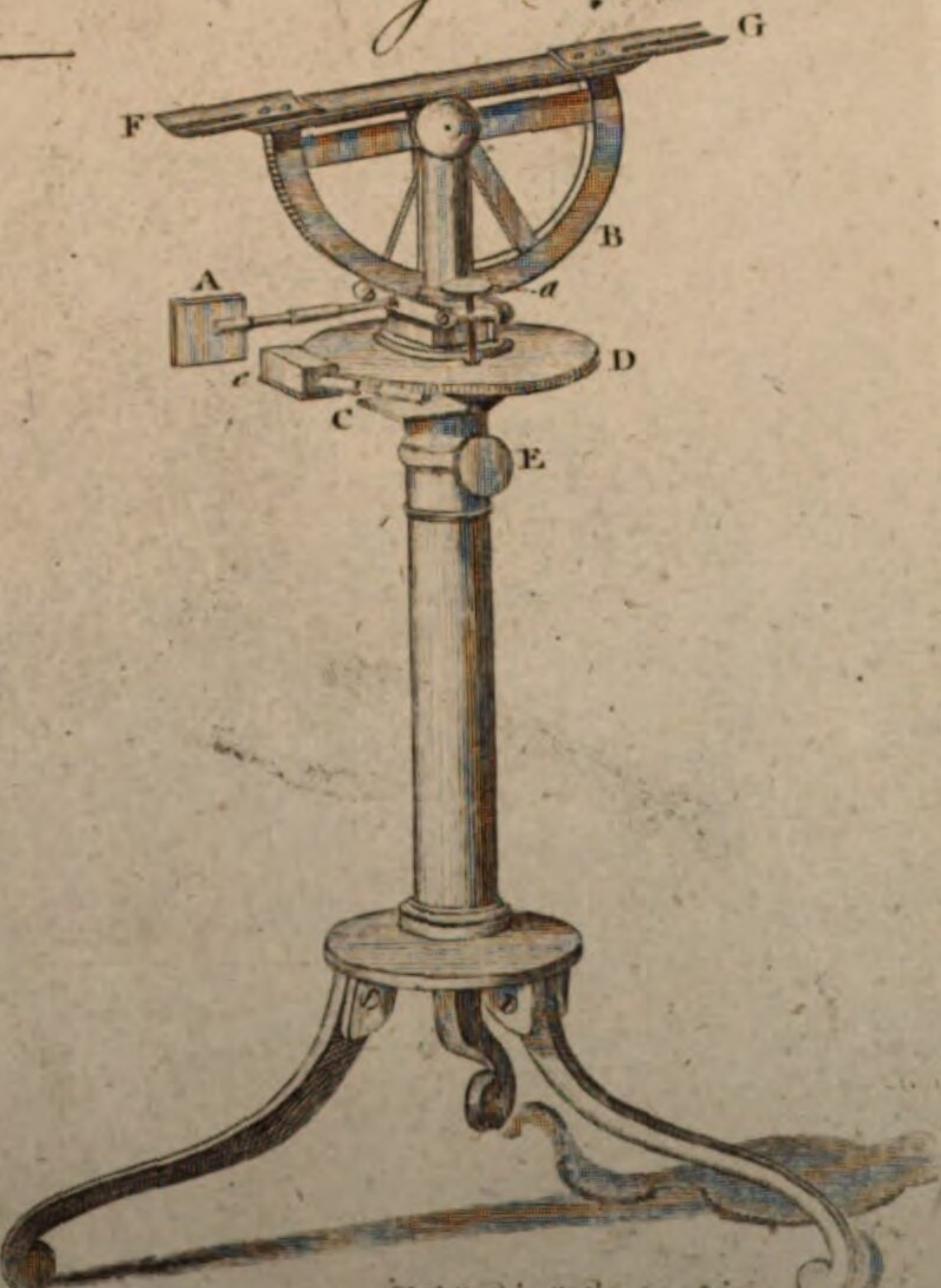
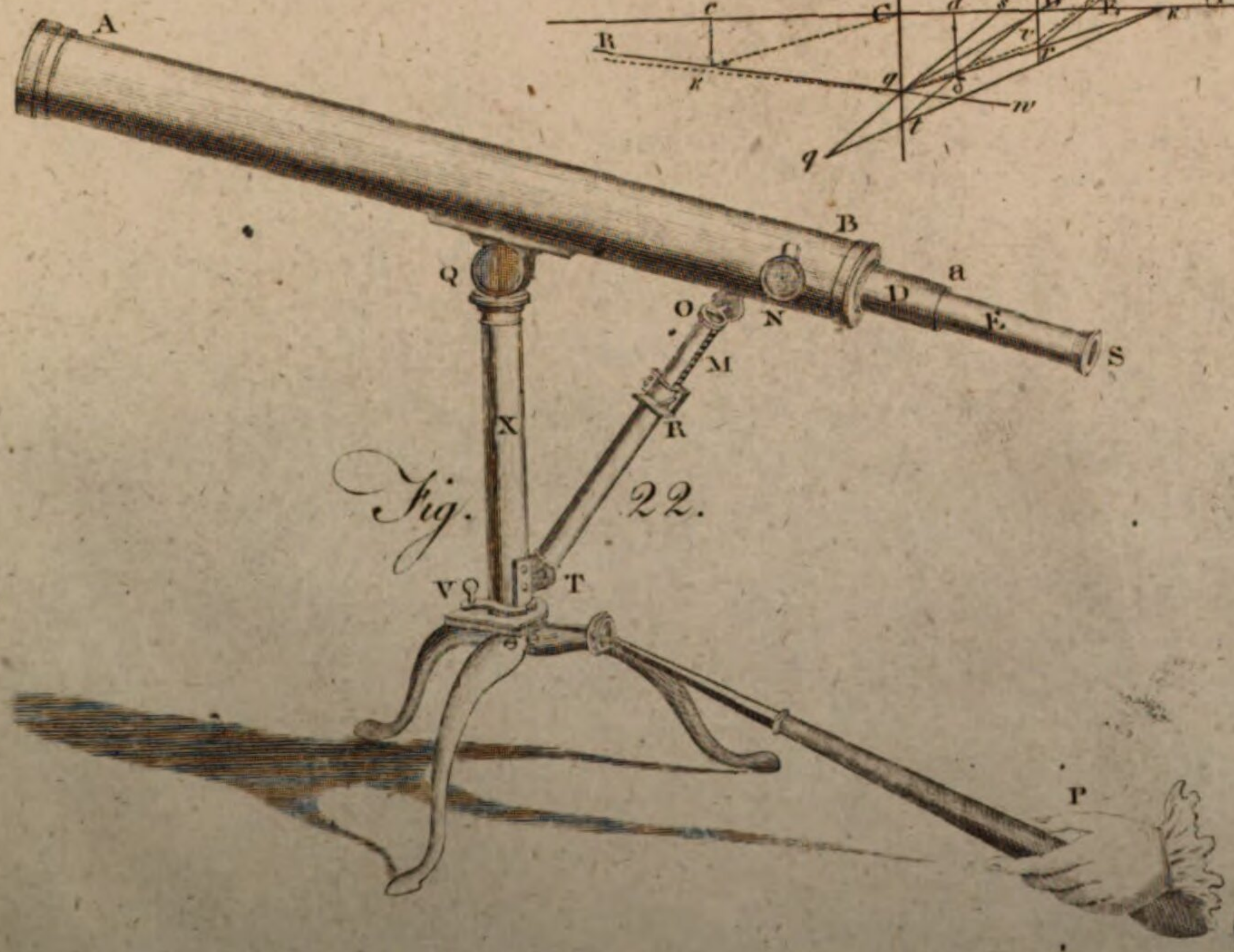


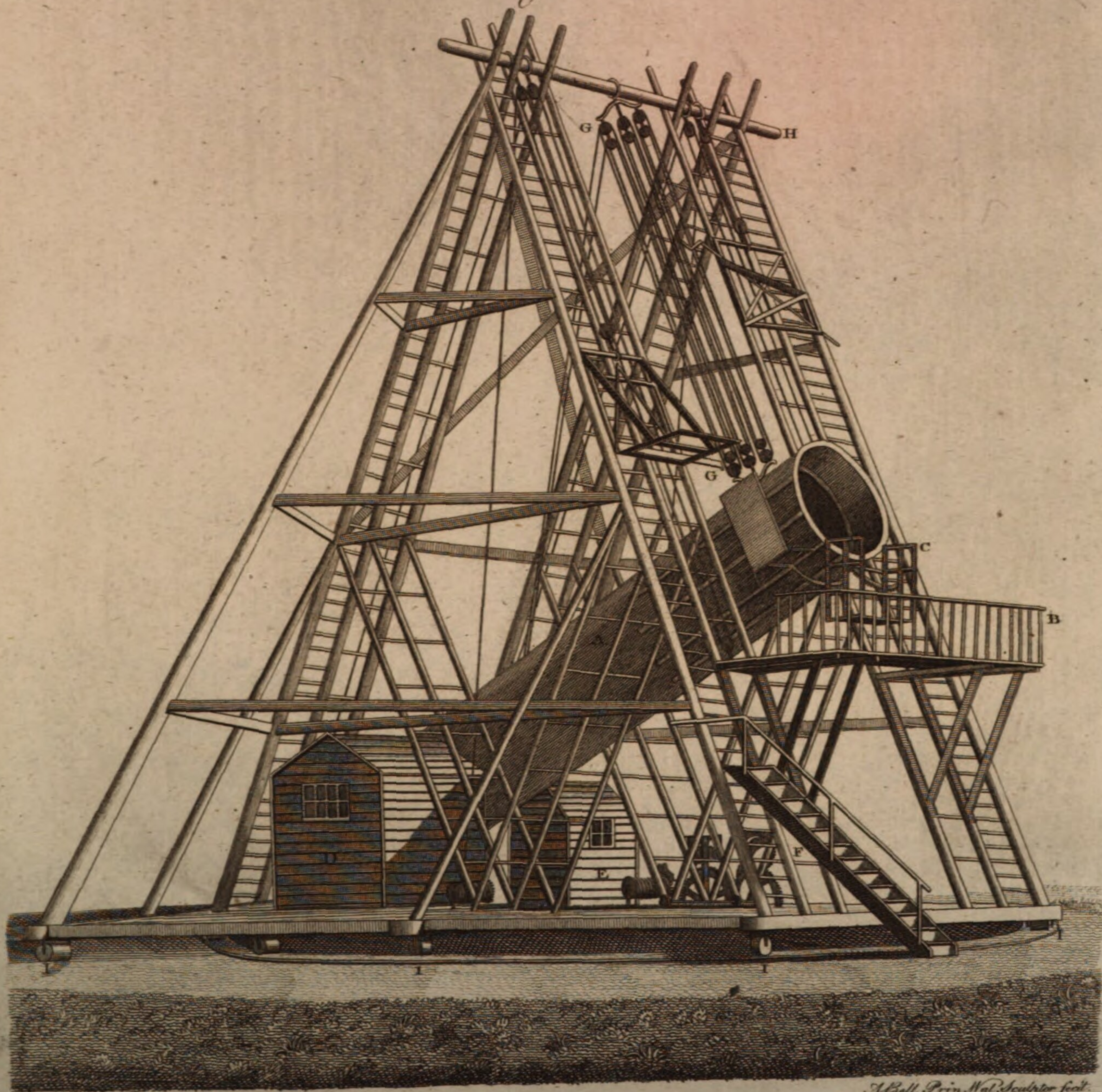
Fig. 22.



Herschels Grand
TELESCOPE.

Plate DV.

Fig. 24.



Ad. Ball. Prin. Wal. Sculptor fecit.

Telescope. fixed in any position, and then any small movements may be given it by the finger plates A and C.

This stand is very subject to brisk tremor, either from external agitation of the pedestal, or from the immediate action of the wind; and we have seldom seen distinctly through telescopes mounted in this manner, till one end of the tube was pressed against something that was very steady and unelastic. It is quite astonishing what a change this produces. We took a very fine telescope made by James Short, and laid the tube on a great lump of soft clay, pressing it firmly down into it. Several persons, ignorant of our purpose, looked through it, and read a table of logarithms at the distance of 310 yards. We then put the telescope on its stand, and pointed it to the same object; none of the company could read at a greater distance than 235 yards, although they could perceive no tremor. They thought the vision as sharp as before; but the incontrovertible proof of the contrary was, that they could not read at such a distance.

If the round plates were of much greater dimensions; and if the lower one, instead of being fixed to the pillar, were supported on four stout pillars standing on another plate; and if the vertical arch had a horizontal axis turning on two upright frames firmly fixed to the upper plate—the instrument would be much freer from tremor. Such stands were made formerly; but being much more bulky and inconvenient for package, they have gone into disuse.

The high magnifying powers of Dr Herschel's telescopes made all the usual apparatus for their support extremely imperfect. But his judgment, and his ingenuity and fertility in resource, are as eminent as his philosophical ardour. He has contrived for his reflecting telescopes stands which have every property that can be desired. The tubes are all supported at the two ends. The motions, both vertical and horizontal, are contrived with the utmost simplicity and firmness. We cannot more properly conclude this article than with a description of his 40 feet telescope, the noblest monument of philosophical zeal and of princely munificence that the world can boast of.

Plat DV. represents a view of this instrument in a meridional situation, as it appears when seen from a convenient distance by a person placed to the south-west of it. The foundation in the ground consists of two concentric circular brick walls, the outermost of which is 42 feet in diameter, and the inside one 21 feet. They are two feet six inches deep under ground; two feet three inches broad at the bottom, and one foot two inches at the top; and are capped with paving stones about three inches thick, and twelve and three quarters broad. The bottom frame of the whole apparatus rests upon these two walls by twenty concentric rollers III, and is moveable upon a pivot, which gives a horizontal motion to the whole apparatus, as well as to the telescope.

The tube of the telescope A, though very simple in its form, which is cylindrical, was attended with great difficulties in the construction. This is not to be wondered at, when its size, and the materials of which it is made, are considered. Its length is 39 feet four inches; it measures four feet ten inches in diameter; and every part of it is of iron. Upon a moderate computation, the weight of a wooden tube must have exceeded an iron one at least 3000 pounds; and its durability would have been far inferior to that of iron. It is made of rolled or sheet iron, which has been joined together without rivets, by a kind of seaming well known to those who make iron-funnels for stoves.

Very great mechanical skill is used in the contrivance of the apparatus by which the telescope is supported and directed. In order to command every altitude, the point of

support is moveable; and its motion is effected by mechanism, so that the telescope may be moved from its most backward point of support to the most forward, and, by means of the pulleys GG suspended from the great beam H, be set to any altitude, up to the very zenith. The tube is also made to rest with the point of support in a pivot, which permits it to be turned sidewise.

The concave face of the great mirror is 48 inches of polished surface in diameter. The thickness, which is equal in every part of it, remains now about three inches and a half; and its weight, when it came from the cast was 2118 pounds, of which it must have lost a small quantity in polishing. To put this speculum into the tube, it is suspended vertically by a crane in the laboratory, and placed on a small narrow carriage, which is drawn out, rolling upon planks, till it comes near the back of the tube; here it is again suspended and placed in the tube by a peculiar apparatus.

The method of observing by this telescope is by what Dr Herschel calls the *front view*; the observer being placed in a seat C, suspended at the end of it, with his back towards the object he views. There is no small speculum, but the magnifiers are applied immediately to the first focal image.

From the opening of the telescope, near the place of the eye-glass, a speaking pipe runs down to the bottom of the tube, where it goes into a turning joint; and after several other inflections, it at length divides into two branches, one going into the observatory D, and the other into the work-room E. By means of the speaking pipe the communications of the observer are conveyed to the assistant in the observatory, and the workman is directed to perform the required motions.

In the observatory is placed a valuable sidereal time-piece, made by Mr Shelton. Close to it, and of the same height, is a polar distance-piece, which has a dial-plate of the same dimensions with the time-piece: this piece may be made to show polar distance, zenith distance, declination or altitude, by setting it differently. The time and polar distance pieces are placed so that the assistant sits before them at a table, with the speaking pipe rising between them; and in this manner observations may be written down very conveniently.

This noble instrument, with proper eye-glasses, magnifies above 6000 times, and is the largest that has ever been made. Such of our readers as wish for a fuller account of the machinery attached to it, viz. the stairs, ladders, and platform B, may have recourse to the second part of the Transactions of the Royal Society for 1795; in which, by means of 18 plates and 63 pages of letter-press, an ample detail is given of every circumstance relating to joiner's work, carpenter's work, and smith's work, which attended the formation and erection of this telescope. It was completed on August the 28th 1789, and on the same day was the sixth satellite of Saturn discovered.

TELL (William), an illustrious Swiss patriot, chief instrument of the revolution which delivered the Swiss cantons from the German yoke in 1307. Grissler, the governor of these provinces for the emperor Albert, having ordered him, under pain of death, to shoot at an apple placed on the head of one of his children; he had the dexterity, though the distance was very considerable, to strike it off without hitting the child. The tyrant, perceiving he had another arrow concealed under his cloak, asked him for what purpose? To which he boldly replied, "To have shot you thro' the heart, if I had had the misfortune to kill my son." The enraged governor now ordered him to be hanged; but his fellow-citizens, animated by his fortitude and

Tell
Temper.

patriotism, flew to arms; attacked and vanquished Griffer, who was shot to death by Tell; and the association for the independency took place that instant.

TELL-Tale, a name sometimes given to the *Perpetual-Log*. See that article.

TELLER, an officer of the exchequer, in ancient records called *tailier*. There are four of these officers, whose duty is to receive all sums due to the king, and to give the clerk of the pells a bill to charge him therewith. They likewise pay all money due from the king, by warrant from the auditor of the receipt; and make weekly and yearly books both of their receipts and payments, which they deliver to the lord treasurer.

TELLINA, in natural history, a genus of animals belonging to the class of *vermes*, and order of *testacea*. The animal is a tethys; the shell is bivalve, generally sloping to one side, with three teeth at the hinge. Gmelin reckons about 90 species.

The tellins bury themselves in the mud or sand at the bottom of the sea, keeping a communication with the water above by means of short tubes or pipes.

TEMISSA, a large town in Africa, about 120 miles north-east of Mourzouk, the capital of Fezzan. Here the caravan of pilgrims from Bornou and Nigritia, which takes its departure from Mourzouk, and travels by the way of Cairo to Mecca, usually provides the stores of corn and dates, and dried meat, that are requisite for its dreary passage.

TEMPE (anc. geog.), a most pleasant place or valley of Thessaly. That it was there, appears from the epithets *Thessalica* (Livy), *Thessala* (Ovid); but in what particular district is the question. From the Phthiotica of Catullus, it should seem to be of Phthiotis: but the Peneus, which ran through Tempe, was at too great a distance, being separated from it by Mount Othrys and others. First, however, we shall define Tempe, previous to the determining the particular district in which it lay. The Peneus, according to Pliny, running down between Ossa to the south and Olympus to the north for 500 stadia, is for half that space navigable: in the direction of this course lies what is called *Tempe*, extending in length for five miles, in breadth for almost an acre and an half, with gentle convexities rising on the right and left beyond ken of human sight. Within glides the Peneus in its verdant light, green in its pebbles, charming in the grass on its banks, harmoniously vocal with the music of birds. In this description Strabo and Ælian agree; the last adding, that it has an agreeable variety of places of retreat; and that it is not the work of man's hand, but the spontaneous production of nature; and Strabo says, that formerly the Peneus formed a lake in this spot, being checked in its course by the higher grounds about the sea; but that an opening being made by an earthquake, and Mount Ossa torn from Olympus, the Peneus gained a free course between them. But Livy, who calls Tempe a grove, remarks a degree of horror rather than amenity, with which the Roman army was struck on marching over the narrow pass; for, besides the defile, difficult to go over, which runs on for five miles, there are steep rocks on each hand, down which the prospect is apt to cause a dizziness, heightened by the noise and depth of the interfluent Peneus. Hence it appears that Tempe was in the Pelasgiotis, whose extremity was formerly the Peneus, but afterwards, as is probable, allotted to Magnesia; and thus Pliny places the mouth of the Peneus not in Thessaly itself, but in the Magnesia of Thessaly.

TEMPER, in a mechanical sense. See **TEMPERING**.

TEMPER, in a moral sense, the disposition of mind whe-

ther natural or acquired. The word is seldom used by good writers without an epithet, as a *good* or *bad* temper; though one of the most beautiful poems in the language is entitled *The Triumphs of Temper*.

It is well observed by an elegant essayist, that more constant uneasiness arises from ill temper than from ill fortune; as a bad temper embitters every sweet, and converts a paradise into a place of torment. For subduing the heart to softness, and preserving a due balance of the passions, a proper culture of the understanding and of the taste is the best method. He who employs his time in the studies of elegant literature, or the fine arts, has almost always a good temper; whilst the man who is absorbed in the pursuits of profound science is apt to acquire a severity of disposition, little less disagreeable, though generally much less pernicious, than the capriciousness of the idler. Music, painting, and poetry, teach the mind to select the agreeable parts of those objects which surround us, and by habituating it to a pure and permanent delight, gradually superinduce an habitual good humour. It is of infinite importance to happiness to accustom the mind, from infancy, to turn from deformed and painful scenes, and to contemplate whatever can be found of moral and natural beauty.

So much of the happiness of private life depends on the government of the temper, that the temper ought to be a principal object of regard in a well-conducted education. The suffering of children to tyrannize without controul over servants and inferiors, is the ruin of many an amiable disposition. The virtues of humanity, benevolence, humility, cannot be too early enforced; at the same time, care should be taken that an infant of two or three years old should never be beaten or spoken to harshly for any offence which it can possibly commit.

TEMPERAMENT, among physicians, the same with constitution, or a certain disposition of the solids and fluids of the human body, by which it may be properly denominated strong, weak, lax, &c.

In every person there are appearances of a temperament peculiar to himself, though the ancients only took notice of four, and some have imagined these were deduced from the theories of the four humours or four cardinal qualities; but it is more probable that they were first founded on observation, and afterwards adapted to those theories, since we find that they have a real existence, and are capable of receiving an explanation. The two that are most distinctly marked are the sanguineous and melancholic, viz. the temperaments of youth and age.

1. *Sanguineous*. Here there is laxity of solids, discoverable by the softness of hair and succulency; large system of arteries, redundancy of fluids, florid complexion; sensibility of the nervous power, especially to pleasing objects; irritability from the plethora; mobility and levity from lax solids. These characters are distinctly marked, and are proved by the diseases incident to this age, as hæmorrhages, fevers, &c. but these, as they proceed from a lax system, are more easily cured.

2. *Melancholic Habit*. Here greater rigidity of solids occurs, discoverable by the hardness and crispature of the hair; small proportion of the fluids, hence dryness and leanness; small arteries, hence pale colour; venous plethora, hence turgescency of these, and lividity; sensibility, frequently exquisite; moderate irritability, with remarkable tenacity of impressions; steadiness in action and slowness of motion, with great strength; for excess of this constitution in maniacs gives the most extraordinary instance of human strength we know. This temperament is most distinctly marked in old age, and in males. The sanguineous tempera-

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ment of youth makes us not distinguish the melancholic till the decline of life, when it is very evident, from diseases of the veins, hemorrhoids, apoplexy, cachexy, obstructions of the viscera, particularly of the liver, dropsies, affections of the alimentary canal, chiefly from weaker influence of the nervous power. So much for the sanguineous and melancholic temperaments; the other two are not so easily explained. The choleric temperament takes place between youth and manhood. In the

3. *Choleric*, the distribution of the fluids is more exactly balanced; there is less sensibility, and less obesity, with more irritability, proceeding from greater tension, less mobility and levity, and more steadiness in the strength of the nervous power. As to the

4. *Phlegmatic*. This temperament cannot be distinguished by any characters of age or sex. It agrees with the sanguineous in laxity and succulency. It differs from that temperament, and the melancholic, by the more exact distribution of the fluids. Again, it differs from the sanguineous, by having less sensibility, irritability, mobility, and perhaps strength, though sometimes indeed this last is found to be great.

These are the ancient temperaments. The temperaments, indeed, are much more various; and very far from being easily marked and reduced to their genera and species, from the great variety which is observable in the constitutions of different men.

TEMPERAMENT, in music, is defined by Rousseau to be an operation which, by means of a slight alteration in the intervals, causes the difference between two contiguous sounds to disappear, makes each of these sounds seem identical with the other, which, without offending the ear, may still preserve their respective intervals or distances one from the other. By this operation the scale is rendered more simple, and the number of sounds which would otherwise be necessary retrenched. Had not the scale been thus modified, instead of twelve sounds alone, which are contained in the octave, more than sixty would be indispensably required to form what we properly call *modulation* in every tone.

It is proved by computation, that upon the organ, the harpsichord, and every other instrument with keys, there is not, and there scarcely can be, any chords properly in tune, save the octave alone. The cause is this, that though three thirds major, or four thirds minor, ought to form a just octave, those are found to surpass, and these not to reach it.

TEMPERANCE, that virtue which a man is said to possess who moderates and restrains his sensual appetites. It is often, however, used in a much more general sense, as synonymous with moderation, and is then applied indiscriminately to all the passions.

Temperance (says Mr Nelson) is the virtue that bridles our irregular desires; it is nearly allied to prudence, and has a close connection with justice; it calms revenge, and quenches the fire of unjust resentment; it checks the Epicure, and stops the riotous hand of the Bacchanalian; it extinguishes or abates the flames of lust, and banishes every lawless action; it silences the flippant detraction tongue, and gives in its stead a pleasing moderation of speech; it shuts the door against avarice, and proves experimentally, that happiness does not consist in the eager pursuit or acquisition of riches, but in a contented mind; it curbs the strongest of all other passions, gaming, and distinguishes justly the absurdity and folly of making that a dangerous trade, which was only designed as a relaxation and an amusement: temperance, in a word, is the parent of many virtues; the parent of peace, prosperity, health, and joy.

Nothing can be more strange to all observation than the practice of forsaking temperance; since every day's experience proves to us, that intemperance produces the opposite to what we seek. Suppose, when a child is born, we ask the parents what it is they wish in that child; they will answer, life. But as life alone, that is, mere existence, may, by infirmity or other accidents, be very wretched, they will naturally wish for health and happiness. Well then, life, health, and happiness, are the general wishes of parents for their children. Now let us see how their wishes are likely to succeed. Their first step is usually a shameful neglect of the food of nature, the breast; the next, a blind gratification of their will; the third, an almost total neglect of their manners; and a fourth, the cherishing them in every irregular affection. Where then is the wonder that parents are disappointed? Life and health depend on proper food and other judicious management on one part; and if sick, an obedience to remedies on the other part; and happiness essentially depends in the first place on health; in the next, on the due government of our senses, affections, and passions. See here how much mankind deviate from themselves; how far they depart from their own principles. But what is the remedy? Nothing more obvious. Let parents exercise their reason in all the steps they take for their children's welfare; let them examine right and wrong; let them not only avoid passion, but labour to correct their own errors of judgment, that they may be the better enabled to prevent them in their children; but, particularly, let them fix in them the knowledge, love, and habit, of temperance.

TEMPERING, in the mechanic arts, the preparing of steel and iron, so as to render them more compact, hard, and firm; or even more soft and pliant, according to their respective occasions. See IRON and STEEL.

TEMPESTA. See MOLYN.

TEMPLARS, TEMPLERS, or *Knights of the Temple*, a religious order instituted at Jerusalem in the beginning of the 12th century, for the defence of the holy sepulchre and the protection of Christian pilgrims. They were first called *The poor of the Holy City*, and afterwards assumed the appellation of *Templers*, because their house was near the temple. The order was founded by Baldwin II. then king of Jerusalem, with the concurrence of the pope; and the principal articles of their rule were: That they should hear the holy office throughout every day; or that, when their military duties should prevent this, they should supply it by a certain number of pater nosters: that they should abstain from flesh four days in the week, and on Fridays from eggs and milk-meats: that each knight might have three horses, and one esquire: and that they should neither hunt nor fowl. After the ruin of the kingdom of Jerusalem about 1186, they spread themselves through Germany and other countries of Europe, to which they were invited by the liberality of the Christians. In the year 1228, this order acquired stability, by being confirmed in the council of Troyes, and subjected to a rule of discipline drawn up by St Bernard. In every nation they had a particular governor, called *master of the Temple*, or of the *militia of the Temple*. Their grand-master had his residence at Paris.

The order of Templars flourished for some time, and acquired, by the valour of its knights, immense riches and an eminent degree of military renown: but as their prosperity increased, their vices were multiplied, and their arrogance, luxury, and cruelty rose at last to such a monstrous height, that their privileges were revoked, and their order suppressed with the most terrible circumstances of infamy and severity. Their accusers were two of their own body, and their chief prosecutor Philip the Fair of France, who addressed his complaints

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rance.
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Templars. complaints to Clement V. The pope, though at first unwilling to proceed against them, was under a necessity of complying with the king's desire; so that, in the year 1307, upon an appointed day, and for some time afterwards, all the knights, who were dispersed throughout Europe, were seized and imprisoned, and many of them, after trials for capital crimes, were convicted and put to death. In 1312 the whole order was suppressed by the council of Vienne. A part of the rich revenues they possessed was bestowed upon other orders, especially on the knights of St John, now of Malta, and the rest confiscated to the respective treasuries of the sovereign princes in whose dominions their possessions lay.—The knights Templars, in order to justify the severity with which they were treated, were charged with apostasy to the Saracens, and holding correspondence with them, with insulting the majesty of God, turning into derision the gospel of Christ, and trampling upon the obligation of all laws human and divine. Candidates, it is said, upon admission to this order, were commanded to spit, in token of contempt, upon an image of Christ, and after admission to worship either a cat or a wooden head crowned with gold. It is farther affirmed, that, among them, the odious and unnatural act of sodomy was a matter of obligation; and they are charged with other crimes too horrible to be mentioned, or even imagined. However, though there be reason to believe, that in this order, as well as others of the same period, there were shocking examples of impiety and profligacy; yet that the whole order was thus enormously corrupt, there is no reason to believe. The pope indeed, though he acted with severity, acted with justice. He sent two cardinals to Paris, who, publishing his bull against the order, condemned those Templars who had made the voluntary confession to be burnt by a slow fire. The criminals recanted their former confessions, but acknowledged themselves worthy of death, because they had unjustly accused the order of crimes of which they were innocent. Several authors of those times wrote in defence of the order; and Boccace alleges, that its extirpation was owing to the avarice of the king of France, who coveted the rich possessions the Templars then enjoyed in France.

The king of Arragon was much pressed to treat the Templars in his kingdom as they had been treated in France; but his constant answer was, "We must be first convinced of their guilt, and it will be then time enough to talk of their punishment." The people, however, were in general so provoked against them, that they were compelled to shut themselves up in the fortresses belonging to their order, to prevent their being torn in pieces; which precaution was represented to the king of Arragon as an act of rebellion. He marched, therefore, with a corps of troops against one of these fortresses. The knight who commanded surrendered immediately, and told the king the truth, assuring him that they desired nothing but a fair trial; with which declaration the king was extremely moved, took the whole order into his protection, and forbade any to abuse or insult them under the heaviest penalties. At the same time he declared, he was ready to receive any informations against them that were supported by proofs; but if the informers failed therein, he would punish them as they deserved.

These facts plead strongly for the innocence of the Templars, or at least they prove that their guilt must have been exaggerated; and if we add, that many of the accusations advanced against them flatly contradict each other, and that many members of this unfortunate order solemnly avowed their innocence while languishing under the severest tortures, and even with their dying breath—it would seem probable, that king Philip set on foot this bloody tragedy, with

a view to gratify his avarice, and glut his resentment against the Templars, and especially against their grand-master, who had highly offended him. The principal cause of his invincible hatred against them was, that in his quarrel with Boniface VIII. the knights espoused the cause of the pope, and furnished him with money to carry on the war. They originally wore a white habit, with red crosses sewed upon their cloaks as a mark of distinction.

TEMPLE (Sir William), was born in London in the year 1628. The family from which he sprung was ancient, and is said to have assumed the surname of Temple from the manor of Temple, in the hundred of Sparken-Hall, in Leicestershire. He was first sent to school at Penshurst, in Kent, under the care of his uncle, the celebrated Dr Hammond, then minister of that parish; but at the age of ten he was removed thence to a school at Bishop-Stortford, in Hertfordshire. When he had acquired a sufficient knowledge of the Greek and Latin, he returned home at the age of fifteen; and, two years after, he went to Cambridge, where he was placed under the tuition of the learned Dr Cudworth, then fellow of Emanuel College. His father, Sir John Temple, being a statesman, seems to have designed him for the same way of life; and on this account, after residing at Cambridge two years, which were principally spent in acquiring a competency of French and Spanish, both languages exceedingly useful for his intended pursuits, he was sent abroad to finish his education.

Mr Temple began his travels by visiting France in 1648. As he chose to pass through the Isle of Wight, where his majesty was detained a prisoner, he there accidentally met with the second daughter of Sir Peter Osborn of Chickland, in Bedfordshire, then governor of Guernsey for the king; and this lady being on a journey with her brother to St Maloes, where their father then was, our young traveller joined their party. This gave rise to an honourable amour, which, at the end of seven years, concluded in a happy marriage. Having resided two years in France, and learned the French language perfectly, Mr Temple made a tour through Holland, Flanders, and Germany, during which he became completely master of the Spanish. In 1654 he returned from the continent, and, marrying Miss Osborn, passed his time in retirement with his father, his two brothers, and a sister, then in Ireland, happy in that perfect harmony which has been so often remarked in their family.

As he rejected all offers made him of employment under Cromwell, the five years which he lived in Ireland were spent chiefly in improving himself in history and philosophy; but at the Restoration, in 1660, being chosen a member of the convention there, while others were trying to make their court to the king, Mr Temple opposed the poll-bill with so much spirit, that his conduct soon attracted the attention of the public, and brought him into notice. In the succeeding parliament, in 1661, he was elected with his father for the county of Carlow; and, in the year following, he was chosen one of the commissioners to be sent from that parliament to the king, which gave him an opportunity of waiting on the duke of Ormond, the new lord-lieutenant, then at London. Soon after he went back to Ireland, but with a resolution of quitting that kingdom, and of removing with his family to England.

On his return he met with a very favourable reception from the duke of Ormond; and soon acquired such a considerable share in his esteem, that the duke complained of him as the only man in Ireland that had never asked any thing from him. When he mentioned his design of carrying his family to England, his grace said, that he hoped he would

Temple. would at least give him leave to write in his favour to the two great ministers, Clarendon then lord chancellor, and the earl of Arlington, who was secretary of state. This the duke did in such strong terms, as procured him the friendship of these two noblemen, as well as the good opinion of the king. Mr Temple, however, made no other use of this advantage than to tell lord Arlington, that if his majesty had any employment abroad, which he was fit for, he should be happy to undertake it; but, at the same time, he requested that he might not be sent into any of the northern climates, to which he had a very great aversion. Lord Arlington replied, he was very sorry he had made such an objection, as there was no other employment then undisposed of except that of going envoy to Sweden. However, in 1665, about the beginning of the first Dutch war, lord Arlington sent a messenger to acquaint him that he must immediately come to his house; which he did, and found that his lordship's business was to tell him, that the king had occasion to send some person abroad upon an affair of the utmost importance, and that he had resolved to make him the first offer; but that he must know, without delay, and without telling him what it was, whether he would accept of it, and that he must be ready to set out in two or three days, without mentioning it to any of his friends. After a little consideration, Mr Temple told his lordship, that, as he took him to be his friend, and as he had advised him not to refuse, as it would be an entrance into his majesty's service, he should consult no farther. This business was to carry a secret commission to the bishop of Munster; which he set out with on the second of August, and executed so much to the satisfaction of Charles II. that, on his return to Brussels, his majesty appointed him resident there, and created him a baronet. As Brussels was a place which he had long wished to reside at, in April 1666 he sent for his family; but, before their arrival, he had been again obliged to depart upon business to the prelate's court: for the bishop having listened to terms of accommodation with France, Sir William wrote two letters to dissuade him from that alliance; and these not having the desired effect, he went in disguise to Munster, where, though he arrived too late to secure the prince in his first engagement, yet he prevailed on him to permit five or six thousand of his best troops to enter into the Spanish service. In this journey he passed for a Spanish envoy, having twenty Spanish guards to attend him. In this manner he first went to Dusseldorp, where the duke of Newburgh, though in the French interest, gave him a guard to Dortmund; but when he reached that place, finding the gates shut, he was forced to proceed to a village, at the distance of a league, which, being full of Brandenburg troops, he was under the necessity of lodging in a barn, upon a straw bed, with his page for a pillow. Next day he was entertained at a castle belonging to the bishop of Munster, by one Gorges a Scotch lieutenant-general in that prelate's service, with what he calls a very episcopal way of drinking. The general coming to the large hall, in which stood a great many flaggons ready charged, he called for wine to drink the king's health. A silver bell, that might hold about two quarts, was upon this brought him; and, as soon as he received it, he pulled out the clapper, and giving it to Sir William, to whom he intended to drink, ordered the bell to be filled. When this was done, he drank off the contents to his majesty's health; and asking Sir William for the clapper, put it on, and turning down the bell, rang it, to shew that he had drank fair, and left nothing in it. He then took out the clapper, desired Sir William to give it to whomsoever he pleased; and, ordering the bell to be filled again, presented it to Sir William: but as the latter seldom used to

Temple. drink, he had generally some gentleman with him to supply his place in this respect whenever it might be necessary. Having finished his business at Munster, he returned to Brussels, where he passed a year with great pleasure and satisfaction.

Two months after the conclusion of the peace with the Dutch at Breda, Sir William's sister, who resided with him at Brussels, being very desirous of seeing Holland, he went thither incognito to gratify her desire; but while he was at the Hague, he paid a private visit to Mr De Witt, in which he laid the foundation of that close intimacy which afterwards subsisted between them.

In the spring of 1667, a new war breaking out between France and Spain, which exposed Brussels to the danger of falling into the hands of the former, Sir William sent his lady and family to England; but he himself remained there with his sister till the Christmas following, when he was ordered by the king to come over privately to London. Taking the Hague in his way, he paid another visit to De Witt, and, pursuant to his instructions, proposed those overtures to him which produced the triple alliance. Soon after his arrival at the British court, he returned, on the 16th of January 1668, with the character of envoy extraordinary and plenipotentiary to Holland; where a conference being opened, he brought that treaty to a perfect conclusion in the short space of five days. The ratifications of this alliance being exchanged on the 15th of February, he repaired to Brussels; and a treaty being set on foot between France and Spain at Aix-la-Chapelle, he set out for that place on the 24th of April in quality of his majesty's ambassador extraordinary and mediator. Here he arrived on the 27th: and it was chiefly owing to his assistance that the Spaniards were brought to sign the articles of that peace on the second of May. This service being completed, he returned to Brussels, with a view of remaining there in his former station of resident; but he received letters from the earl of Arlington, with the king's order to continue as ambassador, and to serve his country in that quality in Holland, as, on account of the late alliances, his majesty was resolved to renew a character which the crown of England had discontinued there since the time of king James. Sir William being now left at liberty to return to England, embraced the opportunity; and, upon his arrival at London, he was received with every possible demonstration of favour both by the king and the court.

Setting out again for Holland, with his new character of the king's ambassador, he arrived at the Hague in the end of August 1668. Here he enjoyed the confidence of that great minister De Witt, and lived in great intimacy with the prince of Orange, who was then only eighteen years of age; but, in September 1669, he was hurried back to England by lord Arlington, who ordered him to put his foot in the stirrup as soon as he should receive his letter. When Sir William waited on the earl, he found that he had not one word to say to him; for, after making him attend a long time, he only asked him a few indifferent questions respecting his journey. Next day he was received as coolly by the king; but the secret soon came out, and he was pressed to return to the Hague, and pave the way for a war with Holland. This, however, he excused himself from having any hand in; which so much provoked the lord treasurer Clifford, that he refused to pay him an arrear of two thousand pounds due from his embassy. Disgusted with Arlington's behaviour, which was so unlike the friendship he had formerly professed, Sir William now retired to his house at Sheen near Richmond, in Surry; and in this retreat, when free from the hurry of business, he wrote his *Observations on the United Provinces*, and one part of his *Miscellanies*, in the time

Temple. time of the second Dutch war. About the end of summer, however, 1673, the king wishing to put an end to the war, sent for Sir William, and desired him to go to Holland to negotiate a peace; but powers having been sent from thence at this time to the Marquis de Fresno, the Spanish ambassador at London, Sir William was ordered to confer with him; and a treaty was accordingly concluded in three days, and the point carried respecting the superiority of the British flag, which had been so long contested. In June 1674 he was again sent ambassador to Holland to offer the king's mediation between France and the confederates, then at war, which was accepted not long after; Lord Berkeley, Sir William Temple, and Sir Leoline Jenkins, being declared ambassadors and mediators; and Nimeguen, which Sir William had proposed, was at length agreed upon by all parties to be the place of treaty. During his stay at the Hague, the prince of Orange, who was fond of the English language, and of the plain English way of eating, constantly dined and supped once or twice a week at his house; and by this familiarity he so much gained the prince's confidence and esteem, that he had a considerable hand in his marriage with the Princess Mary, daughter of James II.

In July 1676 he removed his family to Nimeguen, where he spent the remainder of that year without making any progress in the treaty; and the year following his son was sent over with letters from the lord treasurer, ordering him to return, and succeed Mr Coventry as secretary of state. In consequence of this order, Sir William came over to England in the spring of 1677; and though the affair of the secretary's place was dropped at his desire, he did not return to Nimeguen that year. About this time, the prince having the king's leave to come over, he soon after married the Princess Mary; and this gave occasion for a new coolness between lord Arlington and Sir William, as he and the lord treasurer Osborn, who was related to Sir William's lady, were only privy to that affair. After the prince and princess were gone to Holland, as the court always seemed inclined to favour France, the king wished to engage Sir William in some negotiations with that crown: but he was so ill satisfied with this proposal, that he offered to give up all pretensions to the office of secretary; and desiring the lord treasurer to acquaint his majesty with his intentions, retired to Sheen, in hopes of being taken at his word. Upon a discovery, however, of the French designs not to evacuate the Spanish towns agreed by the treaty to be delivered up, the king commanded him to go upon a third embassy to the states; with whom he concluded a treaty: by which England engaged, in case France refused to evacuate the towns in forty days, to declare war immediately against that nation: but before half that time was elapsed, one Du Crois was sent from the English court to Holland upon a business which damped all the good humour excited by the treaty there, and which produced such sudden and astonishing changes in this country, as gave Sir William a distaste for all public employments.

In 1679 he went back to Nimeguen, where the French delayed to sign the treaty till the last hour; but having concluded it, he returned to the Hague, whence he was soon after sent for to enter upon the secretary's office, which Mr Coventry at length resolved to resign. He accordingly came over, and went to court, as all his friends hoped, with a full intention of assuming his office; but he started some difficulty, because he had not a seat in the house of commons, thinking that, by his not being a member, the public business would suffer at such a critical time, when the contests between the two parties ran so high that the king thought fit to send the duke of York into Flanders, and the parliament to put the lord treasurer Danby into the

Temple. Tower. After this his majesty still pressed Sir William to be secretary of state; using as an argument for his compliance, that he had nobody to consult with at a time when he had the greatest need of the best advice. Notwithstanding all this, Sir William declined the king's offer, advising him to choose a council in whom he could confide, and upon whose abilities he could depend. This advice the king followed; and the choice of the persons being concerted between his majesty and Sir William, the old council was dissolved four days after, and the new one established, of which the latter was a member.

In 1680 the councils began again to be changed, on the king's illness, at the end of summer, and the duke of York's return privately to court. In this juncture Sir William, endeavouring to bring to the king's favour and business some persons to whom his majesty had taken a dislike, if not an aversion, he met with such treatment from them as gave him a fresh distaste to the court, at which he seldom made his appearance; so that he resided principally at Sheen. Soon after this the king sent for him again; and having proposed that he should go as ambassador into Spain, Sir William consented: but when his equipage was almost ready, and part of the money paid down for it, the king changed his mind, and told him that he would have him defer his journey till the end of the session of parliament, in which he was chosen a member for the university of Cambridge. In this session the spirit of party ran so high that it was impossible to bring the house to any kind of temper. The duke was sent into Scotland; but this would not satisfy them, nor any thing but a bill of exclusion; which Sir William strenuously opposed, saying, that "His endeavour ever should be to unite the royal family, and that he would never enter into any councils to divide them." Not long after this period, the parliament being dissolved by his majesty, without the advice of his privy council, and contrary to what he had promised, Sir William made a bold speech against it; for which he was very ill used by some of those friends who had been most earnest in promoting the last change in the ministry. Upon this he grew quite tired of public business, declined the offer he had of again serving for the university in the next parliament, that was soon after called, and met at Oxford; and seeing his majesty resolved to govern without his parliament, and to supply his treasury through another channel, he retired to Sheen a few days after, whence he sent word by his son, that "he would pass the rest of his days like a good subject, but would never more meddle with public affairs." From that time Sir William lived at this place till the end of that reign and for some time in the next; when having purchased a small seat, called *Moor Park*, near Farnham in Surry, which he conceived a great fondness for on account of its solitude and retirement, and its healthy and pleasant situation, and being much afflicted with the gout, and broken with age and infirmities he resolved to spend the remainder of his life in this agreeable retreat. In his way thither, therefore, he waited on king James, who was then at Windsor, and begged his favour and protection to one "that would always live as a good subject, but, whatever might happen, never again enter upon any public employment;" desiring his majesty to give no credit to any thing he might hear to the contrary. The king, who used to say that Sir William Temple's character was always to be believed, promised him whatever he desired, gently reproached him for not entering into his service, which, he said, was his own fault; and kept his word as faithfully to Sir William as Sir William did to his majesty, during the surprising turn of affairs that soon after followed by the arrival of the prince of Orange. At the time of this happy revolution, in 1688, *Moor-Park* becoming unsafe,

Temple. safe, as it lay in the way of both armies, he went back to the house at Sheen, which he had given up to his son; to whom he refused leave, though importunately begged, to go and meet the prince of Orange at his landing: but after king James's abdication, when the Prince reached Windsor, he went thither to wait upon his highness, and carried his son along with him. The prince pressed him to enter into his service, and to be secretary of state; but his age and infirmities confirming him in the resolution he had made not to meddle any more with public affairs, he was satisfied that his son alone should enjoy his majesty's favour. Mr John Temple was upon this appointed secretary at war; but he had hardly been a week in that office, when he resolved to put an end to his own existence; which he did on the 14th of April 1689, by throwing himself out of a boat, hired for that purpose, in shooting London-bridge; having first put stones into his pocket to make him sink speedily.

In 1694 Sir William had the misfortune to lose his lady, who was a very extraordinary woman, as well as an affectionate wife. He was then considerably turned of sixty; at which age he practised what he had so often declared to be his opinion, that "an old man ought then to consider himself of no farther use in the world except to himself and his friends." After this he lived four years, very much afflicted with the gout; and his strength and spirits being worn out by the infirmities of age, he expired in the month of January 1698. He died at Moor-Park, where his heart was buried in a silver box under the sun-dial in his garden, opposite to a window from which he used to contemplate and admire the works of nature, with his sister, the ingenious lady Gifford. This was according to his will; in pursuance of which his body was privately interred in Westminster Abbey, and a marble monument erected in 1722, after the death of lady Gifford, who resembled him in genius as well as in person, and left behind her the character of one of the best and most constant friends in the world.

Sir William Temple's principal works are, 1. *Memoirs from 1672 to 1692*: They are very useful for those who wish to be acquainted with the affairs of that period. 2. *Remarks upon the State of the United Provinces*. 3. *An Introduction to the History of England*: This is a Sketch of a General History. 4. *Letters written during his last embassies*. And 5. *Miscellanies*, which contain a great many curious pieces that display considerable depth of thought. He was an accomplished gentleman, a sound politician, a patriot, and a great scholar. And if this great idea should perchance be shaded by some touches of vanity and spleen, the reader will be so candid as to consider, that the greatest, wisest, and the best of men, have still some failings and imperfections which are inseparable from human nature.

TEMPLE, *templum*, a public building, erected in honour of some deity, either true or false; and wherein the people meet to pay religious worship to the same. The word is formed from the Latin *templum*, which some derive from the Greek *τεμενω*, signifying the same thing; and others from *τεμνω*, *abscindo*, "I cut off, I separate," in regard a temple is a place separated from common uses; others with more probability derive it from the old Latin word *templare*, "to contemplate." It is certain the ancient augurs gave the name *templa* to those parts of the heavens which were marked out for the observation of the flight of birds. Their formula was this: *Templa tesqua sunt*. Temples were originally all open, and hence received their name. See *Phil. Trans.* n^o 471. sect. 5. where we have an account of an ancient temple in Ireland of the same sort as our famous Stonehenge. The word *templum*, in its primary sense among the old Ro-

Temple. mans, signified nothing more than a place set apart and consecrated by the augurs, whether inclosed or open, in the city or in the fields.

Clemens Alexandrinus and Eusebius refer the origin of temples to the sepulchres built for the dead. This notion has been lately illustrated and confirmed by a variety of testimonies by Mr Farmer in his *Treatise on the Worship of Human Spirits*, p. 373, &c. Herodotus and Strabo will have the Egyptians to have been the first who built temples to the gods. The first erected in Greece is ascribed to Deucalion, by Apollonius, *Argonaut lib. iii.* In antiquity we meet with many people who would not build any temples to their gods for fear of confining them to too narrow bounds. They performed their sacrifices in all places indifferently, from a persuasion that the whole world is the temple of God, and that he required no other. This was the doctrine of the magi, followed by the Persians, the Scythians, the Numidians, and many other nations mentioned by Herodotus, lib. i. Strabo, lib. xv. and Cicero in his second oration against Verres.

The Persians, who worshipped the sun, believed it would wrong his power to inclose him in the walls of a temple, who had the whole world for his habitation; and hence, when Xerxes ravaged Greece, the magi exhorted him to destroy all the temples he met with.

The Sicyonians would build no temple to their goodefa Coronis; nor the Athenians, for the like reason, erect any statue to Clemency, who, they said, was to live in the hearts of men, not within stone walls.

The Bithynians had no temples but the mountains to worship on; nor had the ancient Germans any other but the woods.

Even some philosophers have blamed the use and building of temples, particularly Diogenes, Zeno, and his followers the Stoics. But it may be said, that if God hath no need of temples, men have need of places to meet in for the public offices of religion: accordingly temples may be traced back even into the remotest antiquity. See *Hospinian de Origine Templorum*.

The Romans had several kinds of temples; whereof those built by the kings, &c. consecrated by the augurs, and wherein the exercise of religion was regularly performed, were called, by way of eminence, *templa*, "temples." Those that were not consecrated, were called *ades*. The little temples, that were covered or roofed, they called *adicular*. Those open, *facella*. Some other edifices, consecrated to particular mysteries of religion, they called *fana* and *delubra*.

All these kinds of temples, Vitruvius tells us, had other particular denominations, according to the form and manner of their construction, as will be hereafter specified.

Indeed the Romans outdid all nations with regard to temples: they not only built temples to their gods, to their virtues, to their diseases, &c. but also to their emperors, and that in their life time; instances whereof we meet with in medals, inscriptions, and other monuments. Horace compliments Augustus hereupon, and sets him above Hercules and all the heroes of fable; because those were admitted into temples only after their death, whereas Augustus had his temples and altars while living.

Presenti tibi maturos largimur honores;

Jurandasque tuum per nomen ponimus aras.

Epist. ad Aug.

Suetonius, on this occasion, gives an instance of the modesty of that emperor, who would allow of no temples being erected to him in the city; and even in the provinces, where he knew it was usual to raise temples to the very proconsuls, refused

Temple. refused any but those erected in the name of Rome as well as his own.

The most celebrated temples among the Romans were the Capitol and Pantheon. They had also the temple of Saturn, which served for the public treasury; and the temple of Janus.

The temple at Jerusalem was similar in its plan to the TABERNACLE. The first temple was begun by Solomon about the year of the world 2992, and before Christ 1012 according to some chronologers, and finished in eight years. Great mistakes have been committed respecting the dimensions of this temple, by confounding the emblematical description of Ezekiel with the plain account of it in the books of Kings and Chronicles. It consisted of the holy of holies, the sanctuary, and a portico. The holy of holies was a square room of 20 cubits; the sanctuary, or holy place, was 40 cubits long and 20 broad, consequently the length of both these together was 60 cubits. The portico, which stood before the sanctuary, was 20 cubits long and 10 cubits broad. Whether the portico was separated by a wall from the rest of the temple or not, is not mentioned in scripture. If it was, the whole length of the temple, computing the cubit at 22 inches, did not exceed 110 feet in length and 36 feet 8 inches in breadth. In the portico stood the two brazen pillars called *Jachin* and *Boaz*, which, upon comparing and reconciling the seemingly different account in different places, appear to have been 40 cubits high and about 4 cubits diameter. The court probably at first extended all round the temple. Now we are told, that the court about the tabernacle was 100 cubits long and 50 broad; and as Solomon made every part of the temple about twice as large as the corresponding part in the tabernacle, we have reason to conclude, that the court around the temple was 200 cubits long and 100 broad. According to this description, which is taken from the scripture history, the temple of Solomon was by no means so large as it is commonly represented. Still, however, it was very magnificent in size and splendid in ornament. It was plundered of its treasures in the reign of Rehoboam, and repaired by Joash; it was again spoiled in the time of Ahaz and of Hezekiah; and after being restored by Josiah, was demolished by Nebuchadnezzar in the year of the world 3416, after it had stood 476 years according to Josephus, and according to Usher 428 years.

The second temple was built by the Jews, after their return from the Babylonish captivity, under the direction and influence of Zerubbabel their governor, and of Joshua the high-priest, with the leave and encouragement of Cyrus the Persian emperor, to whom Judea was now become a tributary kingdom. According to the Jews, this temple was destitute of five remarkable appendages, which were the chief glory of the first temple; viz. the ark and mercy-seat, the Shechinah, the holy fire on the altar, which had been first kindled from heaven, the urim and thummim, and the spirit of prophecy. This temple was plundered and profaned by Antiochus Epiphanes, who also caused the public worship in it to cease; and afterwards purified by Judas Maccabæus, who restored the divine worship; and after having stood five hundred years, rebuilt by Herod, with a magnificence approaching to that of Solomon's. Tacitus calls it *immensa opulentiae templum*; and Josephus says, it was the most astonishing structure he had ever seen, as well on account of its architecture as its magnitude, and likewise the richness and magnificence of its various parts and the reputation of its sacred appurtenances. This temple, which Herod began to build about sixteen years before the birth of Christ, and so far completed in nine years and a half as to be fit for divine service, was at length destroyed by the Romans on the same month and day of the month

on which Solomon's temple was destroyed by the Babylonians. Temple.

The Indian temples, or pagodas, are sometimes of a prodigious size. They are commonly erected near the banks of the Ganges, Kistna, or other sacred rivers, for the benefit of ablution in the purifying stream. Where no river flows near the foot of the pagoda, there is invariably in the front of it a large tank or reservoir of water. These are, for the most part, of a quadrangular form, are lined with free-stone or marble, have steps regularly descending from the margin to the bottom, and Mr Crauford observed many between three and four hundred feet in breadth. At the entrance of all the more considerable pagodas there is a portico, supported by rows of lofty columns, and ascended by a handsome flight of stone steps; sometimes, as in the instance of Tripetti*, to the number of more than a hundred. Under this portico, and in the courts that generally inclose the whole building, an innumerable multitude assemble at the rising of the sun; and, having bathed in the stream below, and, in conformity to an immemorial custom over all the East, having left their sandals on the border of the tank, impatiently await the unfolding of the gates by the ministering brahmin. The gate of the pagoda universally fronts the east, to admit the ray of the solar orb; and, opening, presents to the view an edifice partitioned out, according to M. Thevenot in his account of Chitanagar, in the manner of the ancient cave-temples of Elora, having a central nave or body; a gallery ranging on each side; and, at the farther end, a sanctuary, or chapel of the deity adored, surrounded by a stone ballustrade to keep off the populace. Those who wish to peruse a more particular account of the Indian temples may consult Maurice's Indian Antiquities. See also PAGODA and SERINGHAM.

TEMPLE, in architecture. The ancient temples were distinguished, with regard to their construction, into various kinds; as, *Temple in ante*, *Aedes in antis*. These, according to Vitruvius, were the most simple of all temples, having only angular pilasters, called *ante* or *paraſtata*, at the corners, and two Tuscan columns on each side of the doors. *Temple, tetrastyle*, or simple *tetrastyle*, was a temple that had four columns in front and as many behind. Such was the temple of Fortuna Virilis at Rome. *Temple, prostyle*, that which had only columns in its front or fore side; as that of Ceres at Eleusis in Greece. *Temple, amphiprostyle*, or *double prostyle*, that which had columns both before and behind, and which was also tetrastyle. *Temple, periptere*, that which had four rows of insulated columns around, and was exastyle, i. e. had six columns in front; as the temple of Honour at Rome. *Temple, diptere*, that which had two wings and two rows of columns around, and was also octostyle, or had eight columns in front; as that of Diana at Ephesus.

TEMPLES, among us, denote two inns of court in London, thus called, because anciently the dwelling-house of the knights-templars. At the suppression of that order, they were purchased by the professors of the common law, and converted into *hospitia* or inns. They are called the *inner* and *middle temple*, in relation to Essex-house; which was also a part of the house of the templars, and called the *outer temple*, because situated without Temple-Bar. In the middle temple, during the time of the templars, the king's treasure was kept; as was also that of the kings of France in the house templars at Paris. The chief officer was the master of the temple, who was summoned to parliament in 47 Hen. III. and from him the chief minister of the temple-church is still called *master of the temple*.

TEMPLES, in anatomy, a double part of the head, reaching from the forehead and eyes to the two ears. The temples are chiefly formed of two bones called *os temporis*. These

Temporal
||
Tenacity.

These parts, according to physicians, were called *tempora*, from their showing the age or time of a man by the colour of the hair, which turns white in this part before any other; which Homer seems to have been aware of, by his calling men *poliocrotaphi*, *q. d.* "grey-templed."

TEMPORAL, a term generally used for secular, as a distinction from ecclesiastical. Thus we say temporal lords, and spiritual or ecclesiastical lords.

TEMPORALTIES of BISHOPS, are the revenues, lands, tenements, and lay-fees, belonging to bishops, as they are barons and lords of parliament.

The custody of the temporalties of bishops forms a branch of the king's ordinary revenues (see REVENUE).—These, upon the vacancy of the bishopric, are immediately the right of the king, as a consequence of his prerogative in church matters; whereby he is considered as the founder of all archbishoprics and bishoprics, to whom, during the vacancy, they revert. And for the same reason, before the dissolution of abbeys, the king had the custody of the temporalties of all such abbeys and priories as were of royal foundation (but not of those founded by subjects), on the death of the abbot or prior. Another reason may also be given why the policy of the law hath vested this custody in the king; because, as the successor is not known, the lands and possessions of the see would be liable to spoil and devastation if no one had a property therein. Therefore the law has given the king, not the temporalties themselves, but the custody of the temporalties, till such time as a successor is appointed; with power of taking to himself all the intermediate profits, without giving any account to the successor; and with the right of presenting (which the crown very frequently exercises) to such benefices and other preferments as fall within the time of vacation. This revenue is of so high a nature, that it could not be granted out to a subject, before or even after it accrued: but now, by the statute 15 Edw. III. ft. 4. c. 4 & 5. the king may, after the vacancy, lease the temporalties to the dean and chapter; saving to himself all advowsons, escheats, and the like. Our ancient kings, and particularly William Rufus, were not only remarkable for keeping the bishoprics a long time vacant, for the sake of enjoying the temporalties, but also committed horrible wastes on the woods and other parts of the estate; and to crown all, would never, when the see was filled up, restore to the bishop his temporalties again, unless he purchased them at an exorbitant price. To remedy which, king Hen. I. granted a charter at the beginning of his reign, promising neither to sell, nor let to farm, or take any thing from, the domains of the church, till the successor was installed. And it was made one of the articles of the great charter, that no waste should be committed in the temporalties of bishoprics, neither should the custody of them be sold. The same is ordained by the statute of Westminster the first; and the statute 14 Edw. III. ft. 4. c. 4. (which permits a lease to the dean and chapter) is still more explicit in prohibiting the other exactions. It was also a frequent abuse, that the king would, for trifling or no causes, seize the temporalties of bishops, even during their lives, into his own hands: but this is guarded against by statute 1 Edw. III. ft. 2. c. 2.

This revenue of the king, which was formerly very considerable, is now by a customary indulgence almost reduced to nothing: for, at present, as soon as the new bishop is consecrated and confirmed, he usually receives the restitution of his temporalties quite entire and untouched from the king; and then, and not sooner, he has a fee-simple in his bishopric, and may maintain an action for the profits.

TENACITY, in natural philosophy, that quality of bodies by which they sustain a considerable pressure or force

of any kind without breaking. It is the quality opposite to fragility or brittleness. See *STRENGTH of Materials*.

TENACULUM, in surgery, an instrument used in amputation, for pulling out bleeding vessels that are to be tied by ligatures. See *SURGERY*.

TENAILLES and } See FORTIFICATION, Sect. I.
TENAILLIONS. }

§ 3 and 5.

TENANT, one that holds lands or tenements of some lord or landlord, by rent, fealty, &c. See *TENURE*.

TENAWWIT. See *LOXIA*, species 13.

TENCH, in ichthyology. See *CYPRINUS*, species 3.

TENDER, a small ship in the service of men of war, for carrying men, provisions, or any thing else that is necessary.

TENDONS, in anatomy, are white, firm, and tenacious parts, contiguous to the muscles, and usually forming their extremities. See *ANATOMY*, n° 85.

TENEbrio, in natural history, a genus of insects belonging to the order of *Coleoptera*. The antennæ are moniliform, the last joint being roundish; the thorax is plano-convex and marginated; the head projecting, and the elytra are somewhat stiff. Gmelin enumerates about 63 species. The larvæ of some live in damp places under ground among rubbish; of others in flour and different kinds of food, where they undergo their metamorphosis. The perfect insects are very troublesome in houses; eating bread, meat, &c. They precipitately avoid the light; resorting in troops to dark damp cellars, where putrefaction allures and nourishes them. They are all of a very dark gloomy appearance, from which circumstance they take their name.

TENEDOS (anc. geog.), an island on the coast of Troas, at the distance of 40 stadia from the continent, and 80 in compass; with a cognominal Æolian town, and a temple of Apollo Smintheus. Its origin is derived from Tennes or Tenes, who being exposed in a coffer or bog by his father Cygnus the Thracian, at the instigation of the mother-in-law, was by fate carried to this island, made king of it, and at length worshipped as a god on account of his virtues. The island was famous for its earthen ware, for which purpose it had an excellent red clay; and hence Bochart would derive the appellation from *tinedom*, a "red clay." *Tenedia securis*, is a proverbial saying to denote severity; from a law there passed, that persons found in the act of adultery should be put to death; a severity executed on the king's son; and therefore, in the coins of Tenedos, on one are two heads in memorial of the king and his son, and on the reverse an axe, (Aristotle). This island still retains its ancient name; and is one of the smallest islands of the Archipelago, situated near the coast of Lesser Asia, west of the ruins of Troy. It is chiefly rocky, but fertile, being remarkable for producing the best Muscodine wine in the Levant; and its position, thus near the mouth of the Hellespont, has given it importance in all ages; vessels bound toward Constantinople finding shelter in its port, or safe anchorage in the road, during the Etesian or contrary winds, and in foul weather. The emperor Justinian erected a magazine to receive the cargoes of the corn-ships from Alexandria, when detained there. This was a lofty building, two hundred and eighty feet long and ninety broad. The voyage from Egypt was rendered less precarious, and the grain preserved until it could be transported to the capital. Afterwards, during the troubles of the Greek empire, Tenedos experienced a variety of fortune. The pirates, who infested these seas, made it for many years their place of rendezvous; and Othman seized it in 1302, procured vessels, and thence subdued the other islands of the Archipelago. It has continued in the possession of the Turks ever since:

3 B

and

Tenaculum
||
Tenedos.

Blackst.
Comment.
vol. i.

Teneriff and on the eastern side is a pretty large town, seated at the foot of a mountain, with a fine harbour commanded by a castle. E. Long. 27. 0. N. Lat. 29. 30.

TENERIFF, an island of Africa, and one of the Canaries, being the most considerable for riches, trade, and extent. It lies to the south of the island of Salvages, to the west of the Grand Canary, to the north of the island of Gomera, and to the east of that of Palma. It is of a triangular form, being about 45 miles in length and 20 in breadth; and in the centre is the famous *peak*, called by the natives *El Pico de Teyde*, which in clear weather may be seen at the distance of 120 miles, like a thin blue vapour very little darker than the sky.

The most frequented harbour is called *Santa Cruz*, which is on the south side of the island, and where ships with good anchors and cables may be safe in all weathers. At this port is the principal commercial town in the island, called also *Santa Cruz*, in the middle of which is a mole, built at a vast expence for the convenience of landing; between the mole and the town is a fort called *St Philips*, and near it is a steep rocky den or valley, beginning at the sea shore, and running far in land, which would render the attack of an enemy very difficult; there are also other forts for its defence, all joined together by a thick stone wall, and mounted with cannon.

Glas's Historical Account of the Canary Islands.

Santa Cruz is a large town, containing several churches and convents, an hospital, and the best constructed private buildings of any in the Canary islands. It contains about 7000 inhabitants; it is not fortified on the land side, and all the country near it is dry, stony, and barren.

About four leagues to the south of *Santa Cruz*, close to the sea, there is a cave, with a chapel called the *chapel of our Lady of Candelarie*, in which is an image of the Virgin Mary, that is held in as much reverence here as that of Diana was at Ephesus. This chapel is endowed with so many ornaments that it is the richest place in all the seven islands. At a certain season of the year almost all the inhabitants go thither on pilgrimage, and innumerable and incredible stories are related and universally believed concerning this image.

About four miles in land from *Santa Cruz* stands the city of *St Chrystobal de la Laguna*, which is the metropolis of the island, and contains two parish churches and five convents, but has no trade, being inhabited principally by the gentry of the island; the inhabitants are numerous, yet nobody is seen in the streets, which are solitary and desolate, so that grass grows in those that are most frequented. There are many other towns in the island which contain a great number of people, but none are more than three leagues from the sea.

All the fertile ground within a league of the sea is covered with vines; that of the next league is sown with corn, the third is adorned with woods, and above the woods are the clouds, for the island gradually ascends from the sea, rising on all sides till it terminates in the peak, which is the centre.

On the south-east of the island inland from *Candelaria* is a town called *Guimar*, where there are some families which know themselves to be the genuine unmixed offspring of the original natives; but they know nothing of the manners of their ancestors, nor have they preserved any remains of their language. They are fairer than the Spaniards of Andalusia.

Teneriff contains about 96,000 persons, supposed to be equal to the number of inhabitants of all the rest of the seven islands put together. The peasants in general are wretchedly clothed; when they do appear better, they are habited in the Spanish fashion. The men, in a genteeler line, dress

very gayly, and are seldom seen without long swords. It is remarked, that few of them walk with dignity and ease; which may be attributed to the long cloaks they usually wear. The women wear veils: those worn by the lower ranks are of black stuff, those of the higher of black silk; and such among the latter as have any claim to beauty are far from being over careful in concealing their faces by them. The young ladies wear their fine long black hair plaited, and fastened with a comb or a riband on the top of the head.

The common people, and in this they resemble the inhabitants of most of the islands in the Pacific Ocean lately discovered, have in them a strong tendency to thieving; they are besides lazy, and the most importunate beggars in the world. "I observed likewise (says Mr White) that the itch was so common among them, and had attained such a degree of virulence, that one would almost be led to believe it was epidemic there. Some of the women are so abandoned and shameless, that it would be doing an injustice to the prostitutes met with in the streets of London to say they are like them. The females of every degree are said to be of an amorous constitution, and addicted to intrigue; for which no houses could be better adapted than those in *Teneriff*."

"The manufactures carried on here are very few, and the product of them little more than sufficient for their own consumption. They consist of taffeties, gauze, coarse linsens, blankets, a little silk, and curious garters. The principal dependence of the inhabitants is on their wine (their staple commodity), oil, corn, and every kind of stock for shipping. With these the island abounds: and, in their season, produces not only the tropical fruits, but the vegetable productions of the European gardens, in the greatest plenty. *Teneriff* enjoys an agreeable and healthful mediocrity of climate. Indeed none seems better adapted for the restoration of a valetudinarian; as, by going into the mountains, he may graduate the air, and choose that state of it which best suits his complaint. But although the inhabitants are thus healthy, and have so little occasion for medical aid, they loudly complain of the want of knowledge in the professional gentlemen of the island."

The height of the peak of *Teneriff* has been so variously estimated and calculated by different travellers and geographers, that we can only take the mean between the two extremes of their decisions. Dr Halley allows but two miles and a quarter from the level of the sea to the summit of the sugar-loaf, whilst the Spanish account of the Canaries, translated by Mr Glas in 1763, makes it no less than five miles; and others have assigned a height different from both these. That it is an extinguished volcano is universally known; and we are persuaded that the following account of the crater, and of some experiments made on its brink by M. Mongez on the 24th of August 1785, will prove not unacceptable to our chemical readers.

"The crater of the peak of *Teneriff* (says he) is a true sulphur-pit, similar to those of Italy. It is about 50 fathoms long and 40 broad, rising abruptly from east to west. At the edges of the crater, particularly on the under side, are many spiracles, or natural chimneys, from which there exhale aqueous vapours and sulphureous acids, which are so hot as to make the thermometer rise from 9° to 34° of Reaumur. The inside of the crater is covered with yellow, red, or white, argillaceous earth, and blocks of lava partly decomposed. Under these blocks are found superb crystals of sulphur; these are eight-sided rhomboidal crystals, sometimes an inch in length, and, I suppose, they are the finest crystals of volcanic sulphur that have ever been found. The water that exhales from the spiracles is perfectly pure, and not in the least acid, as I was convinced by several experiments."

"The

Teneriff.

"The elevation of the peak above the level of the sea is near 1900 toises; which induced me to make several chemical experiments in order to compare the phenomena with those that occur in our laboratories. I shall here confine myself merely to the results.

"The volatilization and cooling of liquors were here very considerable. Half a minute was sufficient for the dissipation of a pretty strong dose of æther. The action of acids on metals, earths, and alkalis, was slow; and the bubbles which escaped during the effervescence were much larger than ordinary. The production of vitriols was attended with very singular phenomena. That of iron assumed all at once a very beautiful violet colour, and that of copper was suddenly precipitated of a very bright blue colour. I examined the moisture of the air by means of the hygrometer, of pure alkali, and of vitriolic acid; and I thence concluded, as well as from the direction of the aqueous vapours, that the air was very dry; for at the end of three hours the vitriolic acid had suffered hardly any change either in colour or weight; the fixed alkali remained dry, except near the edges of the vessel that contained it, where it was a little moist; and Saussure's hygrometer pointed to 64°, as nearly as the impetuous wind which then blew would permit us to judge.

"Liquors appeared to us to have lost nothing of their smell or strength at this height; a circumstance which contradicts all the tales that have hitherto been related on this head: volatile alkali, ether, spirit of wine, retained all their strength; the smoking spirit of Boyle was the only one that seemed to have lost any sensible portion of its energy. Its evaporation, however, was not the less quick; in 30 seconds, a quantity which I had poured into a cup was entirely volatilized; and nothing remained but the sulphur which tinged the rims and the bottom. When I poured the vitriolic acid on this liquor, there happened a violent detonation, and the vapours that arose had a very sensible degree of heat. I tried to form volatile alkali by decomposing sal ammoniac with the fixed alkali; but the production was slow and hardly sensible, while at the level of the sea this process, made with the same substances, in the same proportions, succeeded very readily and in abundance.

"As I was curious to investigate the nature of the vapours that exhale from the crater, and to know whether they contained inflammable air, fixed air, and marine acid, I made the following experiments: I exposed on the edge of one of the spiracles a nitrous solution of silver in a cup; it remained more than an hour in the midst of the vapours which were continually exhaling, but without any sensible alteration; which sufficiently shews that no vapours of marine acid exhale from the crater. I then poured into it some drops of marine acid, when a precipitation of luna cornea immediately ensued: but instead of being white, as that precipitate generally is, it was of a fine dark violet colour, which quickly became grey, and it assumed the form of small scaly crystals. These were very distinct when looked at with a glass, and they were even visible to the naked eye. I think myself justifiable in attributing this alteration of colour to the vapours of inflammable air, according to some experiments that I have made on the precipitation of luna cornea in such air. Lime-water, exposed for three hours on the margin of the crater, and in the neighbourhood of a spiracle, was not covered with any calcareous pellicle, nor even hardly with any filmy appearance; which proves, in my opinion, not only that no vapours of fixed air exhale from the crater, but that the atmospheric air, which rests upon it, contains very little of that air, and that the inflammable vapours and sulphureous acids alone are sensible and considerable. The electricity of the atmosphere was pretty considerable, for Saussure's electrometer, when held in the hand at the

height of about five feet, indicated three degrees, while on the ground it pointed only to one and a half. The electricity was positive." W. Long. 16. 18. N. Lat. 28. 29.

TENESMUS, in medicine, a name given by medical writers to a complaint which is a continual desire of going to stool, but without any stool being ready to be voided. This is properly no primary disease, but merely a symptomatic one, and differs in degree according to the disease on which it is an attendant. See MEDICINE, n° 111.

TENIERS (David), the Elder, a Flemish painter, born at Antwerp in 1582. He received the first rudiments of his art from the famous Rubens, who highly esteemed him for his promising genius, and with great satisfaction examined and commended his designs. From the school of that celebrated painter Teniers went to finish his studies at Rome. He attached himself to Adam Elsheimer for six years; and from the instructions of two such incomparable masters, he formed to himself a peculiar style, which his son cultivated so happily afterward as to bring it to the utmost perfection. His pictures were small; and his subjects usually shops, laboratories, humorous conversations, and rural festivities. The demand for his pieces was universal; and even his master Rubens thought them an ornament to his cabinet. He died at Antwerp in 1649.

TENIERS (David) the Younger, also an admirable painter, was the son of the former, and was born at Antwerp in 1610. He obtained the name of *Ape of Painting*, from his imitating the manner of different painters with such exactness as to deceive even the nicest judges. He improved greatly under his father, and obtained such reputation as introduced him to the favour of the great. The archduke Leopold William made him gentleman of his bed-chamber; and all the pictures of his gallery were copied by Teniers, and engraved by his direction. The king of Spain and Don Juan of Austria set so high a value on his pictures, that they built a gallery on purpose for them. William prince of Orange honoured him with his friendship; and Rubens not only esteemed his works, but assisted him with his advice. His principal talent lay in landscapes adorned with small figures. He also painted men drinking and smoking, chemists laboratories, country fairs, and the like. His small figures are superior to his large ones. He died in 1694.

The works of the father and son are thus distinguished: The latter discover a finer touch and fresher pencil, greater variety of attitudes, and a better disposition of the figures. The father retained something of the tone of Italy in his colouring, which was stronger than the son's; besides, the son used to put at the bottom of his pictures, David Teniers, junior.

Abraham, another son of David the Elder, was equal, if not superior, to his father and brother in the expression of his characters, and his understanding the *claro obscuro*; though he was inferior in the sprightliness of his touch, and the lightness of his pencil.

TENISON (Dr Thomas), archbishop of Canterbury, was born at Cottenham in Cambridgeshire in 1636: and studied at Corpus Christi college in Cambridge. In his youth, while the fanatical government lasted, he applied himself to physic; but afterward went into orders, and was some time minister of St Andrew's church, Cambridge; where he attended the sick during the plague in 1665, which his parishioners acknowledged by the present of a piece of plate. He showed himself very active against the growth of Popery by his writings both in king Charles and king James's reigns: in 1680 he was presented to the vicarage of St Martin's in the Fields, London, to which parish he made several donations; and among others, endowed

Tenesmus
||
Tenison.

Tennis.

a free school, and built a handsome library, which he furnished with useful books. King William and queen Mary, in 1689, presented him to the archdeaconry of London; in 1691, he was nominated to the see of Lincoln, and in 1694 he succeeded Dr Tillotson as archbishop of Canterbury. He performed all the duties of a good primate for 20 years, and died in 1715.

TENNIS, a play at which a ball is driven by a racket.

Hoyle's
Games im-
proved by
Beaufort.

As many persons would become players at tennis, provided they could easily understand the rudiments of the game, so as to form some judgment of the players, or at least to know who wins and who loses, we have here attempted to give so plain a description of it, that no one can be at a loss, if ever he should bett or play. As to the executive part, it requires great practice to make a good player, so that nothing can be done without it; all we presume to do is to give an insight into the game, whereby a person may not seem a total stranger to it when he happens to be in a tennis court.

The game of tennis is played in most capital cities in Europe, particularly in France, from whence we may venture to derive its origin. It is esteemed with many to be one of the most ancient games in Christendom, and long before king Charles L's time it was played in England.

This game is as intricate as any game whatever; a person who is totally ignorant of it may look on for a month together, without being able to make out how the game is decided. Therefore we shall begin by describing the court in which it is played.

The size of a tennis court is generally about 96 or 97 feet by 33 or 34, there being no exact dimension ascribed to its proportion, a foot more or less in length or width being of no consequence. A line or net hangs exactly across the middle, over which the ball must be struck, either with a racket or board to make the stroke good. Upon the entrance of a tennis-court, there is a long gallery which goes to the dedans, that is, a kind of front gallery, where spectators usually stand, into which, whenever a ball is struck, it tells for a certain stroke. This long gallery is divided into different compartments or galleries, each of which has its particular name, as follows; from the line towards the dedans are the *first gallery*, *door*, *second gallery*, and the *last gallery*, which is called the *service side*. From the dedans to the last gallery are the figures 1, 2, 3, 4, 5, 6, at a yard distance each, by which the chaces are marked, and is one of the most essential parts of the game, as will appear in the following description.

On the other side of the line are also the *first gallery*, *door*, *second gallery*, and *last gallery*; which is called the *hazard-side*. Every ball struck into the last gallery on this side reckons for a certain stroke the same as the dedans. Between the second and this last gallery are the figures 1, 2, to mark the chaces on the hazard-side. Over this long gallery, or these compartments, is a covering, called the *pent-house*, on which they play the ball from the service-side, in order to begin a set of tennis, from which it is called a *service*. When they miss putting the ball (so as to rebound from the pent-house) over a certain line on the service-side, it is deemed a fault, two of which are reckoned for a stroke. If the ball rolls round the pent-house, on the opposite side of the court, so as to fall beyond a certain line described for that purpose, it is called *passe*, reckons for nothing on either side, and the player must serve again.

On the right-hand side of the court from the dedans is what they call the *tambour*, a part of the wall which projects, and is so contrived in order to make a variety in the stroke, and render it more difficult to be returned by the adversary; for when a ball strikes the *tambour*, it varies its direction, and requires some extraordinary judgment to re-

turn it over the line. The last thing on the right hand side Tennis is called the *grill*, wherein if the ball is struck, it is also 15, or a certain stroke.

The game of tennis is played by what they call *sets*; a set of tennis consists of six games: but if they play what is called an advantage-set, two above five games must be won on one side or the other successively, in order to decide; or, if it comes to six games all, two games must still be won on one side to conclude the set; so that an advantage-set may last a considerable time; for which kind of sets the court is paid more than for any other.

We must now describe the use of the chaces, and by what means these chaces decide or interfere so much in the game. When the player gives his service at the beginning of a set, his adversary is supposed to return the ball; and wherever it falls after the first rebound untouched, the chace is called accordingly; for example, if the ball falls at the figure 1, the chace is called at a yard, that is to say, at a yard from the dedans: this chace remains till a second service is given; and if the player on the service side lets the ball go after his adversary returns it, and if the ball falls on or between any of these figures or chaces, they must change sides, there being two chaces; and he who then will be on the hazard side, must play to win the first chace; which if he wins by striking the ball so as to fall, after its first rebound, nearer to the dedans than the figure 1, without his adversary's being able to return it from its first hop, he wins a stroke, and then proceeds in like manner to win the second chace, wherever it should happen to be. If a ball falls on the line with the first gallery door, second gallery, or last gallery, the chace is likewise called at such or such a place, naming the gallery, door, &c. When it is just put over the line, it is called a chace at the line. If the player on the service-side returns a ball with such force as to strike the wall on the hazard-side so as to rebound, after the first hop over the line, it is also called a chace at the line.

The chaces on the hazard-side proceed from the ball being returned either too hard or not quite hard enough; so that the ball after its first rebound falls on this side of the blue line, or line which describes the hazard-side chaces; in which case it is a chace at 1, 2, &c. provided there is no chace depending. When they change sides, the player, in order to win this chace, must put the ball over the line anywhere, so that his adversary does not return it. When there is no chace on the hazard-side, all balls put over the line from the service side, without being returned, reckon for a stroke.

As the game depends chiefly upon the marking, it will be necessary to explain it, and to recommend those who play at tennis to have a good and unbiassed marker, for on him the whole set may depend: he can mark in favour of the one and against the other in such a manner, as will render it two to one at starting, though even players. Instead of which the marker should be very attentive to the chaces, and not be anyway partial to either of the players.

This game is marked in a very singular manner, which makes it at first somewhat difficult to understand. The first stroke is called 15, the second 30, the third 40, and the fourth game, unless the players get four strokes each; in that case, instead of calling it 40 all, it is called *deuce*; after which, as soon as any stroke is got, it is called *advantage*; and in case the strokes become equal again, *deuce* again, till one or the other gets two strokes following, which win the game; and as the games are won, so they are marked and called; as one game love, two games to one, &c. towards the set, of which so many of these games it consists.

Although but one ball at a time is played with, a number of balls are made use of at this game to avoid trouble, and are handed to the players in baskets for that purpose: by which

Tennis. which means they can play as long as they please, without ever having occasion to stoop for a ball.

As to the odds at tennis, they are by no means fixed, but are generally laid as follow :

Upon the first stroke being won between even players, that is, fifteen love, the odds are of the single

game	-	-	-	7 to 4
Thirty love	-	-	-	4 1
Forty love	-	-	-	8 1
Thirty fifteen	-	-	-	2 1
Forty fifteen	-	-	-	5 1
Forty thirty	-	-	-	3 1

The odds of a four game set when the

first game is won, are	-	7 4
When two games love	-	4 1
Three games love	-	8 to 1
When two games to one	-	2 1
Three games to one	-	5 1

The odds of a six game set when the

first game is won, are	-	3 2
When two games love	-	2 1
Three games love	-	4 1
Four games love	-	10 1
Five games love	-	21 1
When two games to one	-	8 5
Three games to one	-	5 2
Four games to one	-	5 1
Five games to one	-	15 1
When three games to two	-	7 4
Four games to two	-	4 1
Five games to two	-	10 1
When four games to three	-	2 1
Five games to three	-	5 1

The odds of an advantage set when

the first game is won, are	5 4
When two games love	7 4
Three games love	3 1
Four games love	5 1
Five games love	15 1
When two games to one	4 3
Three games to one	2 1
Four games to one	7 2
Five games to one	10 1
When three games to two	3 2
Four games to two	3 1
Five games to two	8 1
When four games to three	8 5
Five games to three	3 1
When five games to four	2 1
When six games to five	5 2

The foregoing odds, as before said, are generally laid, but the chaces interfering makes the odds very precarious ; for example, when there is a chace at half a yard, and a set is five games all, and in every other respect equal, the odds are a good five to four ; and if it were six games to five, and forty thirty with the same chace, the odds then would be a guinea to a shilling ; so that it is plain that the odds at this game differ from those of any other : for one stroke will reduce a set, supposing the players to be five games all, from an even wager to three to two, and so on in proportion to the stage of the set.

There are various methods of giving odds at tennis, in order to make a match equal ; and that they may be understood, we shall give the following list of them, with their meanings, so that any person may form a judgment of the advantage received or given.

The lowest odds that can be given, excepting the choice of the sides, is what they call a *bisque*, that is, a stroke to

be taken or scored whenever the player, who receives the advantage, thinks proper : for instance, suppose a critical game of the set to be forty thirty, by taking the *bisque*, he who is forty becomes game, and so in respect of two *bisques*, &c.

The next greater odds are *fifteen*, that is, a certain stroke given at the beginning of each game.

After these, *half thirty*, that is, fifteen one game, and thirty the next. Then follow the whole *thirty*, *forty*, &c,

There are also the following kind of odds which are given, viz.

Round services ; those are services given round the pent-house, so as to render it easy for the *striker-out* (the player who is on the hazard side) to return the ball.

Half court, that is, being obliged or confined to play into the adversary's half-court ; sometimes it is played straight-wise, and at other times across ; both which are great advantages given by him so confined, but the strait half-court is the greatest.

Touch-no-wall, that is, being obliged to play within the compass of the walls, or sides of the court. This is a considerable advantage to him who receives it ; as all the balls must be played gently, and consequently they are much easier to take than those which are played hard, or according to the usual method of play.

Barring the hazards, that is, barring the dedans, tambour, grill, or the last gallery on the hazard-side, or any particular one or more of them.

These are the common kind of odds or advantages given ; but there are many others, which are according to what is agreed by the players : such as playing with *board* against *racket*, *cricket-bat* against *racket*, &c.

The game of tennis is also played by four persons, two partners on each side. In this case, they are generally confined to their particular quarters, and one of each side appointed to serve and strike out ; in every other respect, the game is played in the same manner as when two only play.

Any thing more to be said upon this subject would be needless, as nothing can be recommended, after reading this short account of tennis, but practice and attention, without which no one can become a proficient at the game.

TENOR, or **TENOUR**, the purport or content of a writing or instrument in law, &c.

TENOR, in music, the first mean, or middle part, or that which is the ordinary pitch of the voice, when neither raised to a treble nor lowered to a bass.

TENSE, in grammar, an inflection of verbs, whereby they are made to signify or distinguish the circumstance of time in what they affirm. See **GRAMMAR**.

TENT, in war, a pavilion or portable house. Tents are made of canvass, for officers and soldiers to lie under when in the field. The size of the officers tents is not fixed ; some regiments have them of one size and some of another : a captain's tent and marquee is generally 10½ feet broad, 14 deep, and 8 high : the subalterns are a foot less ; the major's and lieutenant-colonel's a foot larger ; and the colonel's two feet larger. The subalterns of foot lie two in a tent, and those of horse but one. The tents of private men are 6½ feet square, and 5 feet high, and hold five soldiers each. The tents for horse are 7 feet broad and 9 feet deep : they hold likewise five men and their horse accoutrements. — The word is formed from the Latin *tentorium*, of *tendo* "I stretch," because tents are usually made of canvass stretched out, and sustained by poles, with cords and pegs.

TENT, in surgery, a roll of lint made into the shape of a nail with a broad flat head, chiefly used in deep wounds and ulcers. They are of service, not only in conveying medicines to the most intimate recesses and sinuses of the wound, but to prevent the lips of the wound from uniting before it

Tenter
||
Tenths.

is healed from the bottom; and by their assistance grumous blood, fordes, &c. are readily evacuated.

TENTER, **TRIER**, or *Prover*, a machine used in the cloth manufactory, to stretch out the pieces of cloth, stuff, &c. or only to make them even and set them square.

It is usually about $4\frac{1}{2}$ feet high, and for length exceeds that of the longest piece of cloth. It consists of several long square pieces of wood, placed like those which form the barriers of a manege; so, however, as that the lower cross pieces of wood may be raised or lowered as is found requisite, to be fixed at any height by means of pins. Along the cross pieces, both the upper and under one, are hooked nails, called *tenter hooks*, driven in from space to space.

To put a piece of Cloth on the TENTER. While the piece is yet quite wet, one end is fastened to one of the ends of the tenter; then it is pulled by force of arms towards the other end, to bring it to the length required: that other end being fastened, the upper list is hooked on to the upper cross-piece, and the lowest list to the lowest cross-piece, which is afterwards lowered by force, till the piece have its desired breadth. Being thus well stretched, both as to length and breadth, they brush it with a stiff hair brush, and thus let it dry. Then they take it off; and, till they wet it again, it will retain the length and breadth the tenter gave it.

TENTHREDO, the *SAW-FLY*; a genus of insects belonging to the order of *hymenoptera*. The mouth is furnished with jaws, which are horny, arched, dentated within; the right jaw being obtuse at the apex: the lip cylindrical, trifid: there are four feelers, unequal and filiform: the wings are plain and turned: the sting consists of two serrated laminae, and the scutellum of two grains placed at a distance. Gmelin mentions 143 species. These insects are not very shy. Some, by means of their saw, deposit in the buds of flowers, others on the twigs of trees or shrubs, eggs from which are produced caterpillars. The implement with which they are armed is nowise formidable; as it appears only destined to the purpose of depositing their eggs.

TENTHS, and *FIRST FRUITS of Spiritual Preferments*, a branch of the king's revenue. See **REVENUE**.

These were originally a part of the Papal usurpations over the clergy of this kingdom; first introduced by Pandolph the pope's legate, during the reigns of king John and Henry III. in the see of Norwich; and afterwards attempted to be made universal by the popes Clement V. and John XXII. about the beginning of the 14th century. The first fruits, *primisse* or *annates*, were the first year's whole profits of the spiritual preferment, according to a rate or *valor* made under the direction of pope Innocent IV. by Walter bishop of Norwich in 38 Hen. III. and afterwards advanced in value by commission from pope Nicholas III. A. D. 1292, 20 Edw. I.; which valuation of pope Nicholas is still preserved in the exchequer. The tenths, or *decimæ*, were the tenth part of the annual profit of each living by the same valuation; which was also claimed by the holy see, under no better pretence than a strange misapplication of that precept of the Levitical law, which directs, that the Levites "should offer the tenth part of their tithes as a heave-offering to the Lord, and give it to Aaron the high-priest. But this claim of the pope met with vigorous resistance from the English parliament; and a variety of acts were passed to prevent and restrain it, particularly the statute 6 Hen. IV. c. 1. which calls it a *horrible mischief and damnable custom*. But the Popish clergy, blindly devoted to the will of a foreign master, still kept it on foot; sometimes more secretly, sometimes more openly and avowedly: so that in the reign of Henry VIII. it was computed, that

in the compass of 50 years 800,000 ducats had been sent to Rome for first fruits only. And as the clergy expressed this willingness to contribute so much of their income to the head of the church, it was thought proper (when in the same reign the papal power was abolished, and the king was declared the head of the church of England) to annex this revenue to the crown; which was done by statute 26 Hen. VIII. c. 3. (confirmed by statute 1 Eliz. c. 4.); and a new *valor beneficiorum* was then made, by which the clergy are at present rated.

By these last mentioned statutes all vicarages under ten pounds a year, and all rectories under ten marks, are discharged from the payment of first fruits: and if, in such livings as continue chargeable with this payment, the incumbent lives but half a year, he shall pay only one quarter of his first fruits; if but one whole year, then half of them; if a year and a half, three quarters; and if two years, then the whole, and not otherwise. Likewise by the statute 27 Hen. VIII. c. 8. no tenths are to be paid for the first year, for then the first fruits are due: and by other statutes of queen Anne, in the fifth and sixth years of her reign, if a benefice be under L. 50 *per annum* clear yearly value, it shall be discharged of the payment of first fruits and tenths.

Thus the richer clergy being, by the criminal bigotry of their Popish predecessors, subjected at first to a foreign exaction, were afterwards, when that yoke was shaken off, liable to a like misapplication of their revenues through the rapacious disposition of the then reigning monarch; till at length the piety of queen Anne restored to the church what had been thus indirectly taken from it. This she did, not by remitting the tenths and first fruits entirely; but, in a spirit of the truest equity, by applying these superfluities of the larger benefices to make up the deficiencies of the smaller. And to this end she granted her royal charter, which was confirmed by the statute 2 Ann. c. 11. whereby all the revenue of first fruits and tenths is vested in trustees for ever, to form a perpetual fund for the augmentation of poor livings. This is usually called *Queen Anne's bounty*; which has been still farther regulated by subsequent statutes.

TENURE, in law, signifies the manner whereby lands or tenements are held, or the service that the tenant owes to his lord.

Of this kingdom almost all the real property is by the policy of our laws supposed to be granted by, dependent upon, and holden of, some superior lord, by and in consideration of certain services to be rendered to the lord by the tenant or possessor of this property. The thing holden is therefore styled a *tenement*, the possessors thereof *tenants*, and the manner of their possession a *tenure*. Thus all the lands in the kingdom is supposed to be holden, mediately or immediately, of the king; who is styled the *lord paramount*, or above all. Such tenants as held under the king immediately, when they granted out portions of the lands to inferior persons, became also lords with respect to those inferior persons, as they were still tenants with respect to the king; and, thus partaking of a middle nature, were called *mesne* or *middle lords*. So that if the king granted a manor to A, and he granted a portion of the land to B, now B was said to hold of A, and A of the king; or, in other words, B held his lands immediately of A, but mediately of the king. The king therefore was styled *lord paramount*: A was both tenant and lord, or was a *mesne lord*; and B was called *tenant paravail*, or the *lowest tenant*, being he who was supposed to make avail, or profit of the land. In this manner are all the lands of the kingdom holden which are in the hands of subjects: for, according to Sir Edward Coke, in the law of England we have not properly *allodium*, which is the name by which the feudists abroad distinguish such

Tenths,
Tenure.

Blackst.
Comment.
vol. i.

Blackst.
Comment.
vol. ii.

Tenure. such estates of the subject as are not holden of any superior. So that at the first glance we may observe, that our lands are either plainly feuds, or partake very strongly of the feudal nature.

All tenures being thus derived, or supposed to be derived, from the king, those that held immediately under him, in right of his crown and dignity, were called his *tenants in capite*, or *in chief*; which was the most honourable species of tenure, but at the same time subjected the tenants to greater and more burdensome services than inferior tenures did. And this distinction ran through all the different sorts of tenure.

There seem to have subsisted among our ancestors four principal species of lay-tenures, to which all other may be reduced: the grand criteria of which were the natures of the several services or renders that were due to the lords from their tenants. The services, in respect of their quality, were either *free* or *base* services; in respect of their quantity and the time of exacting them were either *certain* or *uncertain*. Free services were such as were not unbecoming the character of a soldier or a freeman to perform; as to serve under his lord in the wars, to pay a sum of money, and the like. Base services were such as were fit only for peasants or persons of a servile rank; as to plough the lord's land, to make his hedges, to carry out his dung, or other mean employments. The certain services, whether free or base, were such as were stinted in quantity, and could not be exceeded on any pretence; as, to pay a stated annual-rent, or to plough such a field for three days. The uncertain depended upon unknown contingencies; as, to do military service in person, or pay an assessment in lieu of it when called upon; or to wind a horn upon the appearance of invaders; which are free services; or to do whatever the lord should command; which is a base or villein service.

From the various combinations of these services have arisen the four kinds of lay-tenure which subsisted in England till the middle of the last century; and three of which subsist to this day. Of these Bracton (who wrote under Henry the Third) seems to give the clearest and most compendious account of any author ancient or modern; of which the following is the outline or abstract: "Tenements are of two kinds, *frank-tenement*, and *villanage*. And of frank-tenements, some are held freely in consideration of homage and knight-service; others in free-socage, with the service of fealty only. And again, of villanages, some are *pure*, and others *privileged*. He that holds in pure villanage shall do whatsoever is commanded him, and always be bound to an uncertain service. The other kind of villanage is called *villein-socage*; and these villein-socemen do villein-services, but such as are certain and determined." Of which the sense seems to be as follows; first, where the service was free, but uncertain, as military service with homage, that tenure was called the *tenure in chivalry*, *per servitium militare*, or by knight-service. Secondly, where the service was not only free, but also certain, as by fealty only, by rent and fealty, &c. that tenure was called *liberum socagium*, or *free socage*. These were the only free holdings or tenements; the others were villenous or servile: as, thirdly, where the service was base in its nature, and uncertain as to time and quantity, the tenure was *purum villanagium*, absolute or pure villanage. Lastly, where the service was base in its nature, but reduced to a certainty, this was still villanage, but distinguished from the other by the name of *privileged villanage*, *villanagium privilegiatum*; or it might be still called *socage* (from the certainty of its services), but degraded by their baseness into the inferior title of *villanum socagium*, villein-socage.

1. The military tenure, or that by knight-service, was

done away by stat. 12 Car. II. For an account of this species of tenure see *FEODAL System*, and *KNIGHT-Service*; and for its incidents, see *RELIEF*, *PRIMER-SEISIN*, *WARDSHIP*, *MARRIAGE*, *FINES*, and *ESCHEAT*.

2. The second species of tenure or free-socage, not only subsists to this day, but has in a manner absorbed and swallowed up (since the statute of Charles the Second) almost every other species of tenure. See *SOCAGE*.

The other grand division of tenure, mentioned by Bracton, is that of villenage, as contradistinguished from *liberum tenementum*, or frank-tenure. And this (we may remember) he subdivides into two classes, pure and privileged villenage: from whence have arisen two other species of our modern tenures.

3. From the tenure of pure villenage have sprung our present copyhold-tenures, or tenure by copy of court-roll at the will of the lord; in order to obtain a clear idea of which, it will be previously necessary to consult the articles *MANOR* and *VILLENAGE*.

As a farther consequence of what has been there explained, we may collect these two main principles, which are held to be the supporters of a copyhold-tenure, and without which it cannot exist; 1. That the lands be parcel of and situate within that manor under which it is held. 2. That they have been demised, or demisable, by copy of court-roll immemorially. For immemorial custom is the life of all tenures by copy; so that no new copyhold can, strictly speaking, be granted at this day.

In some manors, where the custom hath been to permit the heir to succeed the ancestor in his tenure, the estates are styled *copyholds of inheritance*; in others, where the lords have been more vigilant to maintain their rights, they remain copyholds for life only; for the custom of the manor has in both cases so far superseded the will of the lord, that, provided the services be performed or stipulated for by fealty, he cannot in the first instance refuse to admit the heir of his tenant upon his death; nor, in the second, can he remove his present tenant so long as he lives, though he holds nominally by the precarious tenure of his lord's will.

The fruits and appendages of a copyhold-tenure, that it hath in common with free tenures, are fealty, services (as well in rents as otherwise), reliefs, and escheats. The two latter belong only to copyholds of inheritance; the former to those for life also. But, besides these, copyholds have also heriots, wardship, and fines. Heriots, which are agreed to be a Danish custom, are a render of the best beast or other good (as the custom may be) to the lord on the death of the tenant. This is plainly a relic of villein tenure; there being originally less hardship in it, when all the goods and chattels belonged to the lord, and he might have seized them even in the villein's lifetime. These are incident to both species of copyhold; but wardship and fines to those of inheritance only. Wardship, in copyhold-estates, partakes both of that in chivalry and that in socage. Like that in chivalry, the lord is the legal guardian, who usually assigns some relation of the infant tenant to act in his stead; and he, like guardian in socage, is accountable to his ward for the profits. Of fines, some are in the nature of primer-seisins, due on the death of each tenant, others are mere fines for alienations of the lands; in some manors, only one of those sorts can be demanded, in some both, and in others neither. They are sometimes arbitrary and at the will of the lord, sometimes fixed by custom; but, even when arbitrary, the courts of law, in favour of the liberty of copyholders, have tied them down to be reasonable in their extent; otherwise they might amount to disinheritance of the estate. No fine therefore is allowed to be taken upon descents and alienations (unless in particular circumstances) of more

Tenure.

Tenure. more than two years improved value of the estate. From this instance we may judge of the favourable disposition that the law of England (which is a law of liberty) hath always shown to this species of tenants, by removing, as far as possible, every real badge of slavery from them, however some nominal ones may continue. It suffered custom very early to get the better of the express terms upon which they held their lands; by declaring, that the will of the lord was to be interpreted by the custom of the manor; and, where no custom has been suffered to grow up to the prejudice of the lord, as in this case of arbitrary fines, the law itself interposes in an equitable method, and will not suffer the lord to extend his power so far as to disinherit the tenant.

4. There is yet a fourth species of tenure, described by Bracton, under the name sometimes of *privileged villenage*, and sometimes of *villein-socage*. See *Privileged VILLENAGE*.

Having in the present article and those referred to, taken a compendious view of the principal and fundamental points of the doctrine of tenures, both ancient and modern, we cannot but remark the mutual connection and dependence that all of them have upon each other. And upon the whole it appears, that, whatever changes and alterations these tenures have in process of time undergone, from the Saxon era to the 12 Car. II. all lay-tenures are now in effect reduced to two species; free tenure in common socage, and base tenure by copy of court-roll. But there is still behind one other species of tenure, reserved by the statute of Charles II. which is of a spiritual nature, and called the tenure in *FRANK-ALMOIGN*; see that article.

A particular account of the ancient tenures would to many persons be highly amusing. We can only select a few of the most singular, referring the curious reader for more information to Anderson's *Origin of Commerce*, Henry's *History of Britain*, and Blount's *Fragmenta Antiquitates*.

In the 19th of Henry III. Walter Gately held the manor of Westcourt, in Bedington in Surry, yielding yearly to the king one cross-bow, *balistam*, value twelve pence.

Anno tertio Edw. I. Osbert de Lonchamp, knight, held his lands of Ovenhelle in Kent, for personally guarding the king forty days into Wales at his own expence, with one horse of five shillings value, one sack worth sixpence, and one broch for that sack. *N. B.* All personal services, or attendances on our kings in those times, were limited to forty days, at their own expence.

The like the same year of Laurence de Broke, who for his hamlet of Renham in Middlesex, found the king one soldier, a horse worth five shillings, a sack worth fivepence, and a broch worth twopence (this broch was a kind of cup, jug, pot, or basin), for forty days, at his own expence, wherever his army shall be within the four seas. This was settled (says Mr. Blount) at the Stone Cross, which stood near the May-pole in the Strand, London, where the judges itinerant used in old times to sit.

Robert Maunsel's tenure of lands in Peverel paid the same service, and the horse, sack, and broch, of the same prices.

13mo Edw. I. Henry de Averning's tenure of the manor of Morton in Essex, was to find a man, a horse worth ten shillings, four horse-shoes, a leather sack, and an iron broch.

The year following, three persons held thirty acres of land in Carleton in Norfolk, by the service of bringing the king, whenever he shall be in England, twenty-four pasties of fresh herrings, at their first coming in.

Another held his manor in Norfolk of that king, by annually supplying him at his exchequer with two vessels, call-

ed *mues*, of wine made of pearmain. "Here (says our author) it is worth observing, that in King Edward the First's time pearmain cyder was called *wine*." This therefore seems to account for the mention of vineyards in old times in Kent, Suffex, and other parts of England, which has so often puzzled many people to elucidate.

Another person, in the 21st of the said king, held thirty acres of land, valued at ten shillings yearly in the exchequer, or fourpence *per acre*, in Cambridgeshire, for furnishing a truss of hay for the king's necessary-house or privy, whenever he shall come into that county.

Another, in the 34th of that king, held a manor in Kent, for providing a man to lead three greyhounds when the king shall go into Gascony, so long as a pair of shoes of fourpence should last.

And that we may not again recur to these old tenures, we shall further add, from the same author, that in the first year of king Edward II. Peter Spileman made fine to the king for his lands by serjeanty, to find one to serve as a soldier for forty days in England, with a coat of mail; also to find straw for the king's bed, and hay for his horse.

This article of straw for the king's bed we did not so much wonder at, when we found it in an article in William the Conqueror's time; but it is somewhat more remarkable so late as the days of king Edward the Second.

Several others, we find, held their lands of the crown in those times by very different tenures. One, by paying two white capons annually; another, by carrying the king's standard whenever he happens to be in the county of Suffex; another, by carrying a rod or baton before the king on certain occasions; another, by serving the office of chamberlain of the exchequer, a very good place at present; another, by building and upholding a bridge; another, by being *marechal* (*meretricum*), i. e. as Mr. Blount translates it, of the laundresses in the king's army; another, by acting as a serjeant at arms for the king's army whilst in England; one supplies a servant for the king's larder; another, for his wardrobe; others, to find servants for this or that forest; another, a hawk; one presents the king a pair of scarlet hose annually; others are bound to supply soldiers with armour for certain days, for the keeping this or that cattle; one, viz. for the manor of Elston in Nottinghamshire, pays yearly rent of one pound weight of cummin seed, two pair of gloves, and a steel needle; another, is to repair the iron-work of the king's ploughs; Ela Countess of Warwick, in the 13th year of king Edward I. held the manor of Hokenorton in Oxfordshire, in the barony of D'Oyly, by the serjeanty of carving at the king's table on his birth-day, and she to have the knife the king then uses at table.

TEOS, one of the twelve Ionian cities, was situated on the south side of the Ionian peninsula, and distinguished by being the place where the poet Anacreon and the historian Hecataeus were born.

TERAPHIM, or THERAPHIM, a word in the Hebrew language, which has exercised much the ingenuity of the critics. It occurs 13 or 14 times in the Old Testament, and is commonly interpreted *idols*. We will not trouble our readers with the numerous conjectures which have been formed respecting the meaning of this word. The only way to determine it, if it be at all possible, would be to examine and compare all the passages in which it occurs, and to consult the ancient translations. Conjectures are useless; every man may make a new one, which will have just as good a title to belief as those which have been already proposed.

TERCERY, one of the largest islands of the Azores, or Western Islands, lying in the Atlantic Ocean. It is about 40 miles in circumference; and surrounded with craggy rocks, which render it almost inaccessible. The soil is fertile,

Terebella fertile, abounding in corn, wine, and fruits; and they have such plenty of cattle, that they supply the ships therewith that call there. However, their principal trade is wood. The inhabitants are lively and well made; and they pretend to a great deal of religion and gallantry at the same time. They pique themselves upon points of honour, and are extremely revengeful. It is their custom to rove about in the night-time in quest of intrigues, and seldom fail in finding women for their purpose. It is subject to Portugal; and Angra is the capital town. W. Long. 27. 1. N. Lat. 28. 45.

TEREBELLA, the PIERCER, in natural history, a genus of insects belonging to the class of *vermes*, and order of *mollusca*. The body is filiform, the mouth placed before; the preputium puts forth a pedunculated tubulous gland. There are several capillary tentacula about the mouth. There are ten species.

TEREBINTHINE *Eleaguery*. See PHARMACY, n^o 599.

TEREBINTHUS, in botany. See PISTACIA.

TEREDO, in natural history, a genus of *vermes* belonging to the order of *testacea*. The animal is a terebella; there are two valves, calcareous, hemispherical, and cut off before, and two lanceolated. The shell is tapering, bending, and capable of penetrating wood. There are only three species; the *navalis*, *utriculus*, and *clava*.

The *navalis*, or ship-worm, which has a very slender smooth cylindrical shell, inhabits the Indian seas, whence it was imported into Europe. It penetrates easily into the stoutest oak-planks, and produces dreadful destruction to the ships by the holes it makes in their sides; and it is to avoid the effects of this insect that vessels require sheathing.

The head of this creature is well prepared by nature for the hard offices which it has to undergo, being coated with a strong armour, and furnished with a mouth like that of the leech; by which it pierces wood, as that animal does the skin; a little above this it has two horns which seem a kind of continuation of the shell; the neck is as strongly provided for the service of the creature as the head, being furnished with several strong muscles; the rest of the body is only covered by a very thin and transparent skin, through which the motion of the intestines is plainly seen by the naked eye; and by means of the microscope several other very remarkable particulars become visible there. This creature is wonderfully minute when newly excluded from the egg, but it grows to the length of four or six inches, and sometimes more.

When the bottom of a vessel, or any piece of wood which is constantly under water, is inhabited by these worms, it is full of small holes; but no damage appears till the outer parts are cut away: Then their shelly habitations come into view; in which there is a large space for inclosing the animal, and surrounding it with water. There is an evident care in these creatures never to injure one another's habitations; by this means each case or shell is preserved entire; and in such pieces of wood as have been found eaten by them into a sort of honeycomb, there never is seen a passage or communication between any two of the shells, tho' the woody matter between them often is not thicker than a piece of writing-paper.

They penetrate some kinds of wood much more easily than others. They make their way most quickly into fir and al-

der, and grow to the greatest size. In the oak they make small progress, and appear small and feeble, and their shells much discoloured.

Since each of these animals is lodged in a solitary cell, and has no access to those of its own species, it has been matter of surprise how they should increase to so vast a multitude. Upon dissecting them, it appears that every individual has the parts of both sexes, and is therefore supposed to propagate by itself.

The sea-worms, which are pernicious to our shipping, appear to have the same office allotted them in the waters which the termites have on the land (see TERMES). They will appear, on a very little consideration, to be most important beings in the great chain of creation, and pleasing demonstrations of that infinitely wise and gracious Power which formed, and still preserves, the whole in such wonderful order and beauty: for if it was not for the rapacity of these and such animals, tropical rivers, and indeed the ocean itself, would be choked with the bodies of trees which are annually carried down by the rapid torrents, as many of them would last for ages, and probably be productive of evils, of which, happily, we cannot in the present harmonious state of things form any idea (A); whereas now being consumed by these animals, they are more easily broken in pieces by the waves; and the fragments which are not devoured become specifically lighter, and are consequently more readily and more effectually thrown on shore, where the sun, wind, insects, and various other instruments, speedily promote their entire dissolution.

TERENCE, or PUBLIUS TERENTIUS AFER, a celebrated comic poet of ancient Rome, was born at Carthage in Africa. He was slave to Terentius Lucanus the senator; who gave him his liberty on account of his wit, his good mien, and great abilities. Terence, on his becoming a freed man, applied himself to the writing of comedies; in the execution of which he imitated Menander and the other celebrated comic poets of Greece. Cicero gives him the most pompous eulogiums, both for the purity of his language and the perspicuity and beauty of his compositions, which he considers as the rule and standard of the Latin tongue; and observes, that they were esteemed so fine and elegant, that they were thought to have been written by Scipio and Lælius, who were then the greatest personages and the most eloquent of the Roman people. Terence died while on a voyage into Greece, about the 15th year before the Christian era. There are six of his comedies extant, of which the best editions are the Elzevir one 1635, 12mo; that *cum integris notis Donati, et selectis variorum*, 1686, 8vo; Westervovius's, in two vols 4to 1726; and that of Bentley the same year 4to. Madam Dacier has given a beautiful French version of this author; and a very good English translation was published in 4to, 1768, by Mr Colman.

TERM, in law, is generally taken for a limitation of time or estate; as, a lease for term of life or years.

Term, however, is more particularly used for that time wherein our courts of justice are open; in opposition to which, the rest of the year is called *vacation*.

TERM, in grammar, denotes some word or expression in a language.

The word *term*, *terminus*, is borrowed metaphorically, by the grammarians and philosophers, from the measurers or sur-

(A) That wood will endure in water for many centuries, is apparent from the oak stakes which were driven into the bed of the river Thames on the invasion of this island by Julius Cæsar, one of which is to be seen in Sir Ashton Lever's museum, and likewise from those bodies of trees which are daily found in the bogs and morasses of Great Britain and Ireland, which after a duration, the former of eighteen hundred, the latter of upwards of two thousand years, are found in a perfect state of preservation.

Terms. veyors of lands: as a field is defined and distinguished by its *termini*, or limits, so is a thing or matter spoken of by the word or term it is denoted by.

TERM in the Arts, or TERM of Art, is a word which, besides the literal and popular meaning which it has or may have in common language, bears a further and peculiar meaning in some art or science.

TERMS, the several times or seasons of the year, wherein the tribunals, or courts of judicature, are open to all who think fit to complain of wrong, or to seek their rights by due course of law, or action; and during which the courts in Westminster-hall sit and give judgment. But the high court of parliament, the chancery, and inferior courts, do not observe the terms; only the courts of king's-bench, common-pleas, and exchequer, which are the highest courts at common law. In contradistinction to these, the rest of the year is called *vacation*.

Of these terms there are four in every year, during which time matters of justice are dispatched. *Hilary-term*, which, at London, begins the 23d day of January, or if that be Sunday, the next day after; and ends the 12th of February following. *Easter-term*, which begins the Wednesday fortnight after Easter-day, and ends the Monday next after Ascension-day. *Trinity-term*, beginning the Friday next after Trinity-Sunday, and ending the Wednesday fortnight after. *Michaelmas-term*, which begins the sixth day of November, and ends the 28th of November following. Each of these terms have also their returns. These terms are supposed by Mr Selden to have been instituted by William the Conqueror; but Sir H. Spelman hath shewn, that they were gradually formed from the canonical constitutions of the church; being no other than those leisure seasons of the year which were not occupied by the great festivals or fasts, or which were not liable to the general avocations of rural business. Throughout all Christendom, in very early times, the whole year was one continual term for hearing and deciding causes. For the Christian magistrates, in order to distinguish themselves from the heathens, who were very superstitious in the observation of their *dies fasti* and *nefasti*, administered justice upon all days alike; till at length the church interposed, and exempted certain holy seasons from being profaned by the tumult of forensic litigations; as, particularly, the time of Advent and Christmas, which gave rise to the winter vacation; the time of Lent and Easter, which created that in the spring; the time of Pentecost, which produced the third; and the long vacation, between midsummer and Michaelmas, which was allowed for the hay-time and harvest. All Sundays also, and some peculiar festivals, as the days of the purification, ascension, &c. were included in the same prohibition, which was established by a canon of the church, A. D. 517, and fortified by an imperial constitution of the younger Theodosius, comprized in the Theodosian code. Afterwards, when our own legal constitution was established, the commencement and duration of our law terms were appointed, with a view to these canonical prohibitions; and it was ordered by the laws of king Edward the Confessor, that from Advent to the octave of the Epiphany, from Septuagesima to the octave of Easter, from the Ascension to the octave of Pentecost, and from three in the afternoon of all Saturdays till Monday morning, the peace of God and holy church shall be kept throughout the whole kingdom.

And so extravagant was afterwards the regard paid to these holy times, that though the author of the Mirror mentions only one vacation of considerable length, containing the months of August and September, yet Britton says, that in the reign of king Edward I. no secular plea could be held, nor any man sworn on the Evangelists, in the time of

Advent, Lent, Pentecost, harvest, and vintage, the days of the great litanies, and all solemn festivals. He adds, that the bishops and prelates granted dispensations for taking assizes and juries in some of these holy seasons, upon reasonable occasions; and soon after a general dispensation was established in parliament by stat. Westm. 1. 3 Edw. I. cap. 51. that assizes of novel disseisin, *mort d'ancestor*, and darrein presentment, should be taken in Advent, Septuagesima, and Lent, as well as inquests; at the special request of the king to the bishops. The portions of time that were not included within these prohibited seasons fell naturally into a fourfold division; and from some festival, or saint's day, that immediately preceded their commencement, were denominated the terms of *St Hilary*, of *Easter*, of the *Holy Trinity*, and of *St Michael*: which terms have been since regulated and abbreviated by several acts of parliament; particularly Trinity-term by stat. 32 Hen. VIII. cap. 2. and Michaelmas-term by stat. 16 Car. I. cap. 6. and again by stat. 24 Geo. II. cap. 48.

TERMS, Oxford. Hilary or Lent-term begins January 14th, and ends the Saturday before Palm-Sunday. Easter-term begins the tenth day after Easter, and ends the Thursday before Whitsunday. Trinity-term begins the Wednesday after Trinity-Sunday, and ends after the act, or 6th of July, sooner or later, as the vice-chancellor and convocation please. Michaelmas-term begins October the 10th, and ends December the 17th.

TERMS, Cambridge. Lent-term begins January the 14th, and ends Friday before Palm-Sunday. Easter-term begins the Wednesday after Easter-week, and ends the week before Whitsunday. Trinity-term begins the Wednesday after Trinity-Sunday, and ends the Friday after the commencement, or 2d of July. Michaelmas-term begins October the 10th, and ends December the 16th.

TERMS, Scottish. The court of session has two terms, the winter and summer. The winter begins on 12th November, and ends 11th March, only there is a recess of three weeks at Christmas. The summer term commences 12th May, and ends 11th July. The court of exchequer has four terms: 1. Candlemas term begins 15th January, and ends 3d February; 2. Whitsuntide term begins 12th May, and ends 2d June; 3. Lammas term begins 17th June, and ends 5th July; 4. Martinmas term begins 24th November, and ends 20th December.

TERMS, Irish. In Ireland the terms are the same as at London, except Michaelmas-term, which begins October the 13th, and adjourns to November the 3d, and thence to the 6th.

TERMES, in entomology; a genus of insects belonging to the order of *aptera*, according to Linnæus, but by others it is arranged more properly under the *neuroptera*. The mouth has two horny jaws; the lip is horny and quadrifid, the laciniae being linear and acute; there are four feelers, which are equal and filiform. The antennae are moniliform in most species, and the eyes two. There are eight species, according to Gmelin; the *fatale*, *destructor*, *arda*, *mordax*, *capense*, *fatidicum*, *pulsatorium*, and *divinatorium*. But as Gmelin has followed the classification of Linnæus in arranging the termes under the order of *aptera*, it is not improbable that several of these which are mentioned as species of the termes may belong to a different genus. It will be sufficient, in the present article, to describe the *fatale*, which we are enabled to do from very accurate information.

The *termes fatale*, *bellicosus*, or white ant, is of a yellow colour above; the wings also yellowish; the costa is ferruginous; the stemmata are near the eyes, the central point being somewhat prominent. Of the white ant we have a very curious and interesting description, in the Philosophical

Termes. *Topical Transactions* for 1781, by Mr Henry Smeathman of Clement's Inn. According to this account, the works of these insects surpass those of the bees, wasps, beavers, and other animals, as much at least as those of the most polished European nations excel those of the least cultivated savages. And even with regard to man, his greatest works, the boasted pyramids, fall comparatively far short, even in size alone, of the structures raised by these insects. The labourers among them employed in this service are not a quarter of an inch in length; but the structures which they erect rise to 10 or 12 feet and upwards above the surface of the earth. Supposing the height of a man to be six feet, the author calculates, that the buildings of these insects may be considered, relatively to their size and that of a man, as being raised to near five times the height of the greatest of the Egyptian pyramids; that is, corresponding with considerably more than half a mile. We may add, that, with respect to the interior construction, and the various members and dispositions of the parts of the building, they appear greatly to exceed that or any other work of human construction.

The most striking parts of these structures are, the royal apartments, the nurseries, magazines of provisions, arched chambers and galleries, with their various communications; the ranges of Gothic-shaped arches, projected, and not formed by mere excavation, some of which are two or three feet high, but which diminish rapidly, like the arches of aisles in perspectives; the various roads, sloping staircases, and bridges, consisting of one vast arch, and constructed to shorten the distance between the several parts of the building, which would otherwise communicate only by winding passages. In some parts near Senegal, their number, magnitude, and closeness of situation, make them appear like the villages of the natives. But these and many other curious instances of the great sagacity and powers of these insects cannot be understood, without viewing the plates in which their feeble frames, and comparatively stupendous works, are delineated. See *Phil. Trans.* above referred to.

The economy of these industrious insects appears to have been very attentively observed by the ingenious author, as well as their buildings. There are three distinct ranks or orders among them, constituting a well-regulated community. These are, first, the *labourers*, or working insects; next the *soldiers*, or fighting order, who do no kind of labour, and are about twice as long as the former, and equal in bulk to about 15 of them; and lastly, the winged or perfect insects, which may be called the *nobility* or *gentry* of the state; for they neither labour nor fight, being scarcely capable even of self-defence. "These only are capable of being elected *kings* or *queens*; and nature has so ordered it, that they emigrate within a few weeks after they are elevated to this state, and either establish new kingdoms, or perish within a day or two."

The first order, the working insects, are most numerous, being in the proportion of 100 to 1 of the soldiers. In this state they are about $\frac{1}{4}$ of an inch long, and 25 of them weigh about a grain, so that they are not so large as some of our ants. See *Plate DI. fig. 1. and 2.*

The second order, or soldiers, have a very different form from the labourers, and have been by some authors supposed to be the males, and the former neuters; but they are, in fact, the same insects as the foregoing, only they have undergone a change of form, and approached one degree nearer to the perfect state. They are now much larger, being half an inch long, and equal in bulk to fifteen of the labourers, (*fig. 3. and 4.*)

The third order, or the insect in its perfect state, varies its form still more than ever. The head, thorax, and ab-

Termes. domen, differ almost entirely from the same parts in the labourers and soldiers; and, besides this, the animal is now furnished with four fine large brownish, transparent, wings, with which it is at the time of emigration to wing its way in search of a new settlement. It differs so much from the other two, that they have not hitherto been supposed to belong to the same community. In fact, they are not to be discovered in the nest till just before the commencement of the rainy season; when they undergo the last change, which is preparative to the formation of new colonies. They are equal in bulk to two soldiers and about 30 labourers (see *fig. 5.*), and by means of the wings with which they are furnished they roam about for a few hours; at the end of which time they lose their wings, and become the prey of innumerable birds, reptiles, and insects: while probably not a pair out of many millions of this unhappy race get into a place of safety, fulfil the first law of nature, and lay the foundation of a new community. In this state many fall into the neighbouring waters, and are eaten with avidity by the Africans. The author found them delicate, nourishing, and wholesome, without sauce or other help from cookery than merely roasting them in the manner of coffee.

The few fortunate pairs who happen to survive this annual massacre and destruction, are represented by the author as being casually found by some of the labourers, that are continually running about on the surface of the ground, and are elected kings and queens of new states. Those who are not so elected and preserved certainly perish, and most probably in the course of the following day. By these industrious creatures the king and queen elect are immediately protected from their innumerable enemies, by inclosing them in a chamber of clay; where the business of propagation soon commences. Their "voluntary subjects" then busy themselves in constructing wooden nurseries, or apartments entirely composed of wooden materials, seemingly joined together with gums. Into these they afterwards carry the eggs produced from the queen, lodging them there as fast as they can obtain them from her. The author even furnishes us with plausible reasons to believe, that they here form a kind of garden for the cultivation of a species of microscopical mushroom; which Mr König (in an Essay on the East Indian Termites, read before the Society of Naturalists of Berlin) conjectures to be the food of the young insects. But perhaps the most wonderful, and at the same time best authenticated, part of the history of these singular insects, is that which relates to the queen or mother of the community in her pregnant state.

After impregnation, a very extraordinary change begins to take place in her person, or rather in her abdomen only. It gradually increases in bulk, and at length becomes of such an enormous size as to exceed the bulk of the rest of her body 1500 or 2000 times. She becomes 1000 times heavier than her consort, and exceeds 20,000 or 30,000 times the bulk of one of the labourers. In this state, the matrix has a constant peristaltic or undulating motion; the consequence of which is (as the author has counted them) (*fig. 8.*) the protrusion of 80,000 eggs in 24 hours.

These eggs, says the author, "are instantly taken from her body by her attendants (of whom there always are, in the royal chamber and the galleries adjacent, a sufficient number in waiting) and carried to the nurseries, which are sometimes four or five feet distant in a straight line.—Here, after they are hatched, the young are attended and provided with every thing necessary, until they are able to shift for themselves, and take their share of the labours of the community."

Many curious and striking particulars are related of the

Termes. great devastations committed by this powerful community; which construct roads, or rather covered ways, diverging in all directions from the nest, and leading to every object of plunder within their reach. Though the mischiefs they commit are very great, such is the economy of nature, that it is probably counterbalanced by the good produced by them; in quickly destroying dead trees and other substances, which, as the author observes, would, by a tedious decay, serve only to encumber the face of the earth. Such is their alacrity and dispatch in this office, that the total destruction of deserted towns is so effectually accomplished, that in two or three years a thick wood fills the space; and not the least vestige of a house is to be discovered.

From the many singular accounts here given of the police of these insects, we shall mention one respecting the different functions of the labourers and soldiers, or the civil and military establishments in this community, on an attempt to examine their nest or city.

On making a breach in any part of the structure with a hoe or pick-axe, a soldier immediately appears, and walks about the breach, as if to see whether the enemy is gone, or to examine whence the attack proceeds. In a short time he is followed by two or three others, and soon afterwards by a numerous body, who rush out as fast as the breach will permit them; their numbers increasing as long as any one continues to batter the building. During this time they are in the most violent bustle and agitation; while some of them are employed in beating with their forceps upon the building, so as to make a noise that may be heard at three or four feet distance. On ceasing to disturb them, the soldiers retire, and are succeeded by the labourers, who hasten in various directions towards the breach, each with a burden of mortar in his mouth ready tempered. Though there are millions of them, they never stop or embarrass each other; and a wall gradually arises that fills up the chasm. A soldier attends every 600 or 1000 of the labourers, seemingly as a director of the works; for he never touches the mortar, either to lift or carry it. One in particular places himself close to the wall which they are repairing, and frequently makes the noise above-mentioned; which is constantly answered by a loud hiss from all the labourers within the dome: and at every such signal, they evidently redouble their pace, and work as fast again.

The work being completed, a renewal of the attack constantly produces the same effects. The soldiers again rush out, and then retreat, and are followed by the labourers loaded with mortar, and as active and diligent as before. "Thus, says the author, the pleasure of seeing them come out to fight or to work alternately may be obtained as often as curiosity excites or time permits: and it will certainly be found, that the one order never attempts to fight, or the other to work, let the emergency be ever so great." The obstinacy of the soldiers is remarkable. "They fight to the very last, disputing every inch of ground so well as often to drive away the negroes, who are without shoes, and make white people bleed plentifully through their stockings."

Such is the strength of the buildings erected by these puny insects, that when they have been raised to little more than half their height, it is always the practice of the wild bulls to stand as sentinels upon them, while the rest of the herd is ruminating below. When at their full height of

10 or 12 feet, they are used by the Europeans as places to look out from over the top of the grass, which here grows to the height of 13 feet upon an average. The author has stood with four men on the top of one of these buildings, in order to get a view of any vessel that might come in sight.

It may appear surprising how a Being perfectly good should have created animals which seem to serve no other end but to spread destruction and desolation wherever they go. But let us be cautious in suspecting any imperfection in the Father of the Universe. What at first sight may seem only productive of mischief, will, upon mature deliberation, be found worthy of that wisdom which planned the most beautiful parts of the world. Many poisons are valuable medicines; the storms are beneficial; and diseases often promote life. These termites, indeed, are frequently pernicious to mankind, but they are also very useful and even necessary; one valuable purpose which they serve is, to destroy decayed trees and other substances, which, if left on the surface of the ground in hot climates, would in a short time pollute the air. In this respect they resemble very much the common flies, which are regarded by mankind in general as noxious, and at best as useless beings in the creation; but this is certainly for want of consideration. There are not probably in all nature animals of more importance; and it would not be difficult to prove, that we should feel the want of one or two species of large quadrupeds much less than of one or two species of these despicable-looking insects. Mankind in general are sensible that nothing is more disagreeable, or more pestiferous, than putrid substances; and it is apparent to all who have made observation, that those little insects contribute more to the quick dissolution and dispersion of putrescent matter than any other. They are so necessary in all hot climates, that even in the open fields a dead animal or small putrid substance cannot be laid upon the ground two minutes before it will be covered with flies and their maggots, which instantly entering quickly devour one part, and perforating the rest in various directions, expose the whole to be much sooner dissipated by the elements. Thus it is with the termites; the rapid vegetation in hot climates, of which no idea can be formed by any thing to be seen in this, is equalled by as great a degree of destruction from natural as well as accidental causes (A). It seems apparent, that when any thing whatever is arrived at its last degree of perfection, the Creator has decreed it shall be totally destroyed as soon as possible, that the face of nature may be speedily adorned with fresh productions in the bloom of spring or the pride of summer: so when trees, and even woods, are in part destroyed by tornadoes or fire, it is wonderful to observe how many agents are employed in hastening the total dissolution of the rest; but in the hot climates there are none so expert, or who do their business so expeditiously and effectually, as these insects, who in a few weeks destroy and carry away the bodies of large trees, without leaving a particle behind, thus clearing the place for other vegetables, which soon fill up every vacancy; and in places where two or three years before there has been a populous town, if the inhabitants, as is frequently the case, have chosen to abandon it, there shall be a very thick wood, and not the vestige of a post to be seen, unless the wood has been of a species which, from its hardness, is called *iron wood*.

Fig.

(A) The Guinea grass, which is so well known and so much esteemed by our planters in the West Indies, grows in Africa, as we have already mentioned, thirteen feet high upon an average, which height it attains in about five or six months; and the growth of many other plants is as quick.

Tania.

Plate DI.

Fig. 1.



Fig. 3.



Fig. 4.



Fig. 5.



Fig. 6.



Fig. 8.



Fig. 2.

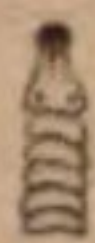


Fig. 7.



Termes.

Fig. 1.



Fig. 2.



Fig. 4.



Fig. 6.



Fig. 3.



Fig. 10.

Fig. 7.



Fig. 5.



Fig. 9.



Fig. 8.



D
A



Termina-
lia
||
Ternstro-
mia.

Fig. 1. represents a labourer. Fig. 2. a labourer magnified. Fig. 3. a soldier. Fig. 4. a soldier, forceps, and part of his head magnified. Fig. 5. a perfect termes bellicosus. Fig. 6. the head of a perfect insect magnified. Fig. 7. a head with stemmata magnified. Fig. 8. a queen. Fig. 9. a king. Fig. 10. is a section of the building raised by these insects, as it would appear on being cut down through the middle from the top a foot lower than the surface of the ground. AA, an horizontal line from A on the left, and a perpendicular line from A at the bottom, will intersect each other at the royal chamber. The darker shades near it are the empty apartments and passages, which it seems are left so for the attendants on the king and queen, who, when old, may require near 100,000 to wait on them every day. The parts which are the least shaded and dotted are the nurseries, surrounded, like the royal chamber, by empty passages, on all sides, for the more easy access to them with the eggs from the queen, the provision for the young, &c. N. B. The magazines of provisions are situated without any seeming order among the vacant passages which surround the nurseries. B, the top of the interior building, which often seems, from the arches carrying upward, to be adorned on the sides with pinnacles. C, the floor of the area or nave. DDD, the large galleries which ascend from under all the buildings spirally to the top. EE, the bridges.

TERMINALIA, in antiquity, feasts celebrated by the Romans in honour of the god Terminus.

TERMINALIA, in botany; a genus of plants belonging to the class of *polygamia*, and order of *monacia*. The male calyx is quinquepartite; there is no corolla; the stamina are ten in number. The hermaphrodite flower is the same with that of the male; there is one style; the fruit, which is a drupe or plum, is below, and shaped like a boat. There are two species; the catappa, and angustifolia or benzoin. This species does not, however, yield benzoin. See STRAX.

TERMINI, in architecture, denotes a kind of statues or columns, adorned on the top with the figure of a man's, woman's, or satyr's head, as a capital; and the lower part ending in a kind of sheath or scabbard.

TERMINUS, in Pagan worship, an ancient deity among the Romans, who presided over the stones or land marks, called *termini*, which were held so sacred, that it was accounted sacrilege to move them; and as the criminal became devoted to the gods, it was lawful for any man to kill him. The worship of this deity was instituted by Numa Pompilius, who, to render land marks, and consequently the property of the people, sacred, erected a temple on the Tarpeian mount to Terminus.

TERN, in ornithology. See STERNA.

TERNATE, the most northerly of the Molucca or Clove Islands in the East Indies. It abounds in cocoa-nuts, bananas, citrons, oranges, almonds, and other fruit proper to the torrid zone; but cloves are the most valuable produce. It is in the possession of the Dutch. Malaya is the capital town. E. Long. 129. 0. N. Lat. 1. 0.

TERNI, a town of Italy in the Pope's territories, and in the duchy of Spoleto, with a bishop's see. It is but a small place; though there are very beautiful ruins of antiquity, it having been a very considerable Roman colony. It is situated on the top of a high mountain, and to the west of it are fields which are extremely fertile. E. Long. 12. 40. N. Lat. 42. 34.

TERNSTROMIA, in botany; a genus of plants belonging to the class of *polyandria*, and order of *monogynia*. The calyx is monophyllous and quinquepartite: the corolla is monopetalous, quinquepartite or sexpartite, globular, and

bell-shaped: the berry is dry, bilocular, and valveless. There is only one species, the meridionalis. Terpander, Terra.

TERPANDER, a celebrated Greek poet and musician. The Oxford marbles tell us that he was the son of Derdeneus of Lesbos, and that he flourished in the 381st year of these records; which nearly answers to the 27th Olympiad, and 671st year B. C. The marbles inform us likewise, that he taught the *nomes*, or airs, of the lyre and flute, which he performed himself upon this last instrument, in concert with other players on the flute. Several writers tell us that he added three strings to the lyre, which before his time had but four; and in confirmation of this, Euclid and Strabo quote two verses, which they attribute to Terpander himself.

The tetrachord's restraint we now despise,
The seven-string'd lyre a nobler strain supplies.

Among the many signal services which Terpander is said to have done to music, none was of more importance than the notation that is ascribed to him for ascertaining and preserving melody, which before was traditional, and wholly dependent on memory. The invention, indeed, of musical characters has been attributed by Alypius and Gauden-tius, two Greek writers on music, and upon their authority by Boethius, to Pythagoras, who flourished full two centuries after Terpander. But Plutarch, from Heraclides of Pontus, assures us that Terpander, the inventor of *nomes* for the cithara, in hexameter verse, set them to music, as well as the verses of Homer, in order to sing them at the public games: And Clemens Alexandrinus, in telling us that this musician wrote the laws of Lycurgus in verse, and set them to music, makes use of the same expression as Plutarch; which seems clearly to imply a written melody.

After enumerating the airs which Terpander had composed, and to which he had given names, Plutarch continues to speak of his other compositions; among which he describes the proems, or hymns for the cithara, in heroic verse. These were used in after-times by the Rhapsodists, as prologues or introductions to the poems of Homer and other ancient writers. But Terpander rendered his name illustrious, no less by his performances both upon the flute and cithara than by his compositions. This appears by the marbles already mentioned; by a passage in Athenæus, from the historian Hellanicus, which informs us that he obtained the first prize in the musical contests at the Carnean games; and by the testimony of Plutarch, who says, that "no other proof need be urged of the excellence of Terpander in the art of playing upon the cithara, than what is given by the register of the Pythic games, from which it appears that he gained four prizes successively at those solemnities."

Of the works of this poet only a few fragments are now remaining.

TERRA AUSTRALIS INCOGNITA, a name for a large unknown continent, supposed to lie towards the South Pole, and which for a long time was sought after by navigators. The late voyages of Captain Cook have ascertained this matter as much as it probably ever will be. (See *SOUTH-Sea*, *Cook's Discoveries*, n° 47, 48, 68, 69. and *AMERICA*, n° 4). On this subject Captain Cook expresses himself as follows: "I had now made the circuit of the Southern Ocean in a high latitude, and traversed it in such a manner as to leave not the least room for the possibility of there being a continent, unless near the pole, and out of the reach of navigation. By twice visiting the tropical sea, I had not only settled the situation of some old discoveries, but made there many new ones, and left, I conceive, very little more to be done even in that part. Thus I flatter myself, that

Terra.

that the intention of the voyage has in every respect been fully answered; the southern hemisphere sufficiently explored; and a final end put to the searching after a southern continent, which has at times engrossed the attention of some of the maritime powers for near two centuries past, and been a favourite theory amongst the geographers of all ages. That there may be a continent, or large tract of land near the pole, I will not deny: on the contrary, I am of opinion there is; and it is probable that we have seen a part of it. The excessive cold, the many islands, and vast floats of ice, all tend to prove that there must be land to the south; and for my persuasion that this southern land must lie or extend farthest to the north, opposite to the Southern Atlantic and Indian Oceans, I have already assigned some reasons; to which I may add, the greater degree of cold experienced by us in these seas than in the Southern Pacific Ocean under the same parallels of latitude."

TERRA FIRMA, in geography, is sometimes used for a continent, in contradistinction to islands.

TERRA FIRMA, otherwise called *New Castile*, or *Castella del Oro*, a country of America, bounded on the north by the North Sea and part of the Atlantic Ocean, by the same sea and Guiana on the east, by the country of the Amazons and Peru on the south, and by the Pacific Ocean and Veragua on the west. It lies between 62 and 83 degrees of west longitude, and between the equator and 12 degrees of north latitude; being upwards of 1200 miles in length from east to west, and 800 in breadth from north to south. It had the name of *Castella del Oro* from the quantities of gold found in the districts of Uraba and other parts; and was first discovered by the celebrated Columbus in his third voyage.

The climate is neither pleasant nor healthy; the inhabitants one part of the year being scorched by the most intense and burning heat, and the other almost drowned with perpetual floods of rain, pouring from the sky with such violence as if a general deluge was to ensue.

In so large a tract of country the soil must necessarily vary. Accordingly, in some parts it is a barren sand, or drowned mangrove land, that will scarce produce any kind of grain; in others it yields Indian corn, balms, gums, and drugs, almost all manner of fruits as well of Old as of New Spain, sugar, tobacco, Brasil wood, and several other kinds of dyeing woods; a variety of precious stones, particularly emeralds and sapphires; venison and other game. The plantations of cacao, or chocolate nuts, in the district of the Caraccas, are esteemed the best in America. The mountains abound with tygers, and, according to some, with lions, and great numbers of other wild beasts. The rivers, seas, and lakes, teem with fish, and also with alligators; and the bowels of the earth were once furnished with the richest treasures, now almost exhausted. The same may be said of the pearl-fisheries on the coast, which are far from being so profitable now as formerly.

Terra Firma is a very mountainous country. *Terra Firma Proper*, in particular, consists of prodigious high moun-

tains, and deep valleys flooded more than half the year. The mountains in the provinces of Carthagena and St Martha, according to Dampier, are the highest in the world; being seen at sea 200 miles off: from these run a chain of hills of almost equal height, quite through South America, as far as the Straits of Magellan, called the *Cordilleras des Andes*. The province of Venezuela also, and district of the Caraccas, the most northerly parts of South America, are almost a continued chain of hills, separated by small valleys, pointing upon the coast of the North Sea. A chain of barren mountains, almost impassable, runs through the province of Popayan from north to south, some whereof are volcanoes; but towards the shores of the Pacific Ocean it is a low country, flooded great part of the year.

The principal rivers of *Terra Firma* are, the Darien, Chagtre, Santa Maria, Conception, Rio Grande or Magdalena, Maricaibo, and Oroonoko.

Terra Firma contains the provinces of *Terra Firma Proper* or Darien, of Carthagena, St Martha, Rio de la Hacha, Venezuela, Comana, New Andalusia or Paria, New Granada, and Popayan.

Terra Firma Proper lies in the form of a crescent, about the spacious bay of Panama, being the isthmus which joins South and North America; and extending in length between the two seas 300 miles, but in breadth, where the isthmus is narrowest, only 60. Here are found gold mines, gold sands, and fine pearls; and though the land is generally rough, there are some fruitful valleys, watered by rivers, brooks, and springs. The chief places are Panama and Porto Bello.

The inhabitants of *Terra Firma* have never been thoroughly subdued, and in all probability never will; as they are a brave and warlike people, have retreats inaccessible to Europeans, and bear an inveterate enmity to the Spaniards. See *DARIEN*.

TERRA JAPONICA, more commonly called *catechu*, a drug formerly supposed to be an extract from the seeds of the areca catechu, but lately discovered by Mr Kerr, assistant surgeon to the civil hospital at Bengal, to be obtained from the *mimosa catechu*. Mr Kerr gives the following account of the manner in which the extract is made: "After felling the trees, the manufacturer carefully cuts off all the exterior white part of the wood. The interior coloured wood is cut into chips, with which he fills a narrow-mouthed unglazed earthen pot, pouring water upon them until he sees it among the upper chips; when this is half evaporated by boiling, the decoction, without straining, is poured into a flat earthen pot, and boiled to one third part; this is set in a cool place for one day, and afterwards evaporated by the heat of the sun, stirring it several times in the day. When it is reduced to a considerable thickness, it is spread upon a mat or cloth, which has previously been covered with the ashes of cow-dung; this mass is divided into square or quadrangular pieces by a string, and completely dried by turning them frequently in the sun until they are fit for sale (A)."

This extract is called *cutt* by the natives, by the English.

(A) "In making the extract, the pale brown wood is preferred, as it produces the fine whitish extract; the darker the wood is, the blacker the extract, and of less value. They are very careful in drying their pots upon the fire before they are used; but very negligent in cutting their chips upon the ground, and not straining the decoction; by which, and the dirty ashes they use, there must be a considerable quantity of earth in the extract, besides what avarice may prompt them to put into it.

"The antiseptic quality of catechu appears from the experiments made by Sir John Pringle. Huxham employed it successfully in cases where a putrid dissolved state of the blood prevailed. This extract is the principal ingredient in an ointment of great repute in India, composed of catechu four ounces, alum nine drams, white resin four ounces; these are reduced

Terra.

Med. Obser.
and Inqui-
ries, vol. v.

Terra
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Terrasson.
Woodville's
Medical
Botany,
vol. ii.

lish *cutch*, and by different authors *terra japonica*, *catechu*, *khaath*, *gate*, *cachou*, &c. "In its purest state it is a dry pulverable substance, outwardly of a reddish colour, internally of a shining dark brown, tinged with a reddish hue; in the mouth it discovers considerable astringency, succeeded by a sweetish mucilaginous taste." According to Lewis, "it dissolves almost totally in water, excepting the impurities; which are usually of the sandy kind, and amounting in the specimens I examined to about one eighth of the mass. Of the pure matter, rectified spirit dissolves about seven-eighths into a deep red liquor: the part which it leaves undissolved is an almost insipid mucilaginous substance."

Uses. Catechu may be usefully employed for most purposes where an astringent is indicated, provided the most powerful be not required. But it is particularly useful in alvine fluxes; and where these require the use of astringents, we are acquainted with no one equally beneficial. Besides this, it is employed also in uterine profluvia, in laxity and debility of the viscera in general, in catarrhal affections, and various other diseases where astringents are necessary. It is often suffered to dissolve leisurely in the mouth, as a topical astringent for laxities and exulcerations of the gums, for aphthous ulcers in the mouth, and similar affections. This extract is the basis of several fixed formulæ in our pharmacopœias, particularly of a tincture and an electuary: but one of the best forms under which it can be exhibited, is that of a simple infusion in warm water, with a proportion of cinnamon or cassia; for by this means it is at once freed from its impurities, and improved by the addition of the aromatic.

TERRA Puzzolana. See PUZZOLANA.

TERRÆ Filius, Son of the Earth, a student of the university of Oxford, formerly appointed in public acts to make satirical and jesting speeches against the members thereof, to tax them with any growing corruptions, &c.

TERRA Sigillata Lemnia. See ADANSŌNIA.

TERRACE, a walk or bank of earth, raised in a garden or court to a due elevation for a prospect. The name is also given to the roofs of houses that are flat, and whereon we may walk.

TERRAQUEOUS, in geography, a name given to our globe, because consisting of land and water.

TERRAS, or *Traas*, in mineralogy, a species of argillaceous earth. It differs but little in its principles from puzzolana, but is much more compact and hard, porous and spongy. It is generally of a whitish yellow colour, and contains more heterogeneous particles, as spar, quartz, shoerl, &c. and something more of calcareous earth; it effervesces with acids, is magnetic, and fusible *per se*. When pulverized, it serves as a cement, like puzzolana. It is found in Germany and Sweden.

A species of red earth has been found in the parish of St Elizabeth in Jamaica, which turns out to be an excellent substitute for terras or puzzolana earth, and may therefore be of great value to the inhabitants of the West Indies.

One measure of this earth, mixed with two of well-slacked lime and one of sand, form a cement that answers extremely well for building any dam or bridge, or any structure in water, for it will soon harden and become like a stone.

TERRASSON (Abbé John), a French writer born at

Lyons in 1669. He distinguished himself in the dispute concerning Homer, between La Motte and Madam Dacier, by writing a *Dissertation contre l'Iliade*. He wrote a political and moral romance called *Sethos*, full of learning and philosophy; and another capital work of his is a French translation of Diodorus Siculus. He died in 1750.

TERRE Verte, in the colour-trade, the name of a green earth much used by painters, both singly for a good standing green, and in mixture with other colours. The name is French, and signifies "green earth."

It is an indurated clay, of a deep bluish green colour, and is found in the earth, not in continued strata or beds, as most of the other earths are, but in large flat masses of different sizes, imbedded in other strata; these break irregularly in the cutting, and the earth is generally brought out of the pit in lumps of different sizes. It is of a fine, regular, and even structure, and not very hard. It is of an even and glossy surface, very smooth to the touch, and in some degree resembling the morochthus or French chalk, but adhering firmly to the tongue. It does not stain the hands in touching it; but being drawn along a rough surface, it leaves an even white line, with a greenish cast.

It does not ferment with acids, and it burns to a dusky brown colour. It is dug in the island of Cyprus, and in many parts of France and Italy. That from the neighbourhood of Verona has been esteemed the best in the world; but of late there has been some dug in France that equals it. There is also an earth dug on Mendip Hills, in the sinking for coal, which, though wholly unobserved, is nearly, if not wholly, of equal value. When scraped, and the finer parts separated, it is ready to be made up with oil for the use of the painters, and makes the most true and lasting green of any simple body they use.

TERRESTRIAL, something partaking of the nature of earth, or belonging to the globe of earth; thus we say, the terrestrial globe, &c.

TERRIER, a small hound to hunt the fox or badger; so called because he creeps into the ground, as ferrets do into the coney-burrows, after the fox, &c.

TERRITORY, in geography, denotes an extent or compass of land, within the bounds or belonging to the jurisdiction of any state, city, or other subdivision of a country.

TERROR. See FEAR and FRIGHT.

TERTIAN FEVER. See MEDICINE, n° 126.

TERTULLIAN, or *QUINTUS SEPTIMUS FLORENTIUS TERTULLIANUS*, a celebrated priest of Carthage, was the son of a centurion in the militia, who served as proconsul of Africa. He was educated in the Pagan religion; but being convinced of its errors, embraced Christianity, and became a zealous defender of the faith. He married, it is thought, after his baptism. Afterwards he took orders, and went to Rome; where, during the persecution under the emperor Severus, he published his Apology for the Christians, which is, in its kind, a masterpiece of eloquence and learning; and at the beginning of the third century he embraced the sect of the Montanists. He lived to a very great age, and died under the reign of Antoninus Caracalla, about the year 216. Many of his works are still extant, in all of which he discovers a great knowledge of the Holy Scriptures, a lively imagination, a strong, elevated, and impetuous style, great eloquence and strength of reasoning; but is some-

Terre
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Tertullian.

reduced to a fine powder, and mixed with the hand, adding olive oil ten ounces, and a sufficient quantity of water, to bring the mass to the consistence of an ointment. To all sores and ulcers in warm climates astringent applications of this kind are found to be peculiarly useful."

Teruncius sometimes obscure. His Apology and Prescriptions are most esteemed. The best editions of his works are those of Rigault; especially that of Venice in 1746, folio. Pamelius and Alix, Mr Thomas, and the Sieur du Fossé, have written his life; and Rigault, M. de l'Aube Epine, Father Petau, and other learned men, have published notes on his works.

TERUNCIVS, in antiquity, a very small brass coin in use among the Romans.

The inconvenience of such very small pieces being soon found, the *teruncius* became disused, but its name is still retained in reckoning, and thus it became a money of account. The *teruncius* at first was a quarter of the *as*, or *libra*; hence, as the *as* contained twelve ounces, the *teruncius* contained three, whence the name, which is formed of the Latin *tres uncia*. *Teruncius* was also used for the quarter of the *denarius*; so that when the *denarius* was at ten *ases*, the *teruncius* was worth two and a half; and when the *denarius* was risen to sixteen, the *teruncius* was worth four. See **DENARIUS**.

TESSELATED PAVEMENTS, those of rich Mosaic work made of curious square marbles, bricks, or tiles, called *tessele* from their resembling dice.

TESSERA, in Roman antiquity, denoted in its primary sense a cube or dye; so called from the Greek word *τεσσαρα*, or *τεσσερα*, *four*; respect being had to its number of sides, distinct from the two horizontal planes above and below. And it was thus distinguished from the *talus*, which being round at each end, contained only four planes or faces on which it could stand; and therefore when thrown had no more than two side faces in view. Hence *ludere talis et ludere tessera* are spoken of by Roman writers as two different games. The syllable **TES**. occurs often in Roman inscriptions. The word *tessera* was applied to many other things, not so much from a similitude in the figure, as from the relation they bore to some other thing of which they were the sign or token; as the points on the upper plane of the dye denoted the good or ill success of the cast.

The *tessera hospitalis* was either public or private. As to the former, we find among the inscriptions published by Gruter instances of two municipal towns which put themselves under the patronage of the Roman governor; and the reciprocal engagement between them, engraved on two copper plates, in the form of an oblong square, with a pediment at the top, is called in both *tessera hospitalis*. The design of it was to cultivate or maintain a lasting friendship between private persons and their families; and gave a mutual claim to the contracting parties and their descendants of a reception and kind treatment at each other's houses, as occasion offered. For which end those *tesserae* were so contrived as best to preserve the memory of that transaction to posterity. And one method of doing this was by dividing one of them lengthwise into two equal parts; upon each of which one of the parties wrote his name, and interchanged it with the other. From this custom came the prevailing expression *tesseram hospitalem confringere*, applied to persons who violated their engagements.

The *tessera frumentaria* were small tallies given by the emperors to the populace at Rome, entitling them to the reception of a quantity of corn from the public at stated seasons. The person who had the inspection of these was called *tesserarius*. They were made of wood and of stone.

There was another kind of *tessera* which intitled persons to a sight of the public games and other diversions, usually made in the form of an oblong square.

The *tessera militaris* was a signal given by the general, or chief commander of an army, as a direction to the soldiers

for executing any duty or service required of them. This, upon urgent occasions, was only vocal; but, in ordinary cases, it was written on a tablet, commonly made of wood. Beside these civil and military *tesserae*, there are others which relate to religious affairs, and may be called *sacred*.

TESSON, or **TESTON**. See **TESTER**.

TESSOUWA, a considerable town in Africa, situated east of Mourzouk, the capital of the kingdom of Fezzan. Near this town a deep and rapid stream is said to have existed, but was overwhelmed by the moving sands so frequent in Africa.

TEST, a vessel used in metallurgy for absorbing the scoria of metallic bodies when melted. See **CUPEL**.

Some of the German writers recommend, both for tests and cupels, a sort of friable opaque stone, called *white spath*, which appears to be a species of gypsum, or of the stones from which plaster of Paris is prepared. The *spath* is directed to be calcined with a gentle fire, in a covered vessel, till the slight crackling, which happens at first, has ceased, and the stone has fallen in part into powder: the whole is then reduced into subtle powder, which is passed through a fine sieve, and moistened with so much of a weak solution of green vitriol as is sufficient for making it hold together. Gellert, however, finds, that if the stone is of the proper kind, which can be known only by trials, calcination is not necessary. Scheffer observes, that these kinds of tests are liable to soften or fall asunder in the fire, and that this inconvenience may be remedied by mixing with the uncalcined stone somewhat less than equal its weight, as eight-ninths of such as has been already used and is penetrated by the scoria of the lead, taking only that part of the old test which appears of a green-grey colour, and rejecting the red crust on the top. Tests or cupels made of the *spath* are said not to require so much caution in melting and heating them as the common ones; it appears, however, from Scheffer's account, that they are less durable than those made of the ashes of bones, though greatly superior to those of wood-ashes. Vegetable ashes, which stand pretty well the testing of silver, can scarcely bear any great quantity of gold, this metal requiring a considerably stronger fire than the other; but bone-ashes answer so effectually, and are among us so easily procurable, that it is not needful for the refiner to search for any other materials; though those who work off large quantities of lead, in order to gain a little silver or gold contained in it, may possibly, in places remote from populous cities, avail themselves of substances similar to the *spath* above-mentioned.

The test, for its greater security, is fixed in the mould in which it was formed; which is sometimes a shallow vessel made of crucible earth or cast-iron, more commonly an iron hoop, with three bars arched downwards across the bottom, about two inches deep, and of different widths, from three or four inches to fifteen or more, according to the quantity of metal to be tested at once. The ashes or earthy powder, moistened as for making cupels, are pressed down in the mould so as to completely fill it or rise a little above the sides; with care to make the mass equally solid, and to put in at once, or at least after the bottom has been pressed close, as much of the matter as will be sufficient for the whole; for any additional quantity will not unite thoroughly with the rest, but be apt to part from it in the fire. The edges are pared smooth, and a portion cut out from the middle with a bent knife, so as to leave a proper cavity, which is smoothed by strewing some dry powder on the surface, and rolling on it a wooden, or rather a glass ball.

The process of testing is often performed in the same manner

Teston
Tess.

Test.

manner as that of cupellation: but where great quantities of base metal are to be worked off from a little gold, recourse is had to a more expeditious method, that of testing before the bellows.

An oval test is placed in a cavity, made in a hearth of a convenient height, and some moistened sand or ashes pressed round it to keep it steady: the nose of a bellows is directed along its surface, in such a manner, that if ashes are sprinkled in the cavity of the test, the bellows may blow them completely out: some have an iron plate fixed before the bellows, to direct the blast downwards. To keep the surface of the test from being injured in putting in the metal, some cloths or pieces of paper are interposed. The fuel consists of billets of barked oak laid on the sides of the test, with others laid crosswise on these: the bellows impel the flame on the metal, clear the surface of ashes or sparks of coal, hasten the scorification of the lead, and blow off the scoria, as fast it forms, to one end of the test, where it runs out thro' a notch made for that purpose. About two thirds of the scorified lead may thus be collected; the rest being partly absorbed by the test, and partly dissipated by the action of the bellows. Care must be taken not to urge the blast too strongly, lest some portion of the gold should be carried away by the fumes impetuously forced off from the lead, and some minute particles of it entangled and blown off with the scoria.

TEST-ACT, in law, is the statute 25 Car. II. cap. 2. which directs all officers, civil and military, to take the oaths, and make the declaration against transubstantiation, in the court of King's Bench or Chancery, the next term, or at the next quarter-sessions, or (by subsequent statutes) within six months after their admission; and also within the same time to receive the sacrament of the Lord's Supper, according to the usage of the church of England, in some public church, immediately after divine service or sermon, and to deliver into court a certificate thereof, signed by the minister and church warden, and also to prove the same by two credible witnesses, upon forfeiture of 500*l.* and disability to hold the said office.

The avowed object of this act was to exclude from places of trust all members of the church of Rome; and hence the dissenters of that age, if they did not support the bill when passing through the two houses of parliament, gave it no opposition. For this part of their conduct they have been often censured with severity, as having betrayed their rights from resentment to their enemies. But is this a fair state of the case? Were any rights in reality betrayed? That the dread of a popish successor and of popish influence was the immediate and urgent cause of passing the *test-act*, is indeed true; but that the legislature, when guarding against an impending evil, had not likewise a retrospect to another from which they had so recently been delivered, is not so evident. If it be proper to support an established church as a branch of the constitution, and if the *test-act* be calculated to afford that support to the church of England, it is probable that the deliberations of parliament were as much influenced by the dread of puritanic fury, and a renewal of the covenant, as by apprehensions of a persecution from a popish king and popish councils. That the members of the church established by law in England had as much reason to dread the effects of power in the hands of Puritans as in the hands of Papists, no impartial man will controvert, who is not a stranger to that period of our national history; and that it was the duty of the legislature by every method in their power to provide for the security of the constitution against the machinations of both its enemies, will be admitted by all but such as are in love

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with anarchy on the one hand, or with despotism on the other.

Test.

Many people, when they talk or write of the *test-act*, seem to think that it was framed in opposition to the religious opinions of the church of Rome; and finding the Protestant dissenters, who abhor these opinions, deprived by it of their civil rights, they speak with indignation of a law which confounds the innocent with the guilty. But all this proceeds from a palpable mistake of the purpose of the test. As the legislature had no authority to make laws against any opinions whatever, on account of their being false in theology; so it is not to be supposed that, in their deliberations on the *TEST-ACT*, the members of that august body took into their consideration the comparative orthodoxy of the distinguishing tenets of the Catholics and Puritans. As a religious sect they might esteem the latter much more than the former; but if they found that both had combined with their theological doctrines opinions respecting civil and ecclesiastical government, inconsistent with the fundamental principles of the English constitution, they had an undoubted right to enact a law, by which none should be admitted to offices, in the execution of which they could injure the constitution, without previously giving security that their administration should support it in all its branches. It had not then been doubted, nor is there reason to doubt yet, but that an established religion is necessary, in conjunction with civil government, to preserve the peace of society; and therefore in every well regulated state an established religion must be supported, not because it is the duty of the civil magistrate to conduct his subjects to future happiness, but because he cannot without such an establishment preserve among them present tranquillity. The establishment which must best answer this purpose, is that which, teaching the great and unchangeable duties of morality, is most acceptable in its government and forms of worship to the majority of the people; and therefore in giving a legal establishment to one constitution of the church in preference to all others, it is only this circumstance, and not the comparative purity of the rival churches, viewed merely as ecclesiastical corporations, to which it is the business of the legislature to pay attention. At the time when the *test-act* passed the two houses of parliament, the established church of England was certainly more acceptable to the great body of the people and to all ranks in the state, than any one of the sects, whether Catholic or Protestant, which dissented from her; and therefore it was the duty of the legislature to preserve to that church all her privileges and immunities, and to prevent those hostile sectaries from doing her injury in the discharge of any civil office with which they might be entrusted. It was with this view that the *test-act* was formed; and it is with the same view that the legislature has hitherto rejected every petition for its repeal. In doing so, it deprives no man of his rights, far less of rights which conscience calls upon him to maintain at every hazard; for the rights of individuals to hold civil offices are not inherent, but derived from the legislature, which of course must be the judge upon what terms they are to be held. The legislature of England has excluded from many offices, civil and military, every man who will not give security, that in the discharge of his public duty he will support the church established by law; and as the test of his intention, it requires him, before he enters upon his office, to renounce the doctrine of transubstantiation, and receive the sacrament of the Lord's Supper in some public church, according to the liturgy of the church of England. Whether this be the most proper test that could have been exacted, may well be questioned; but that in a country abounding with sectaries of various denominations,

Test. minations, who agree in nothing but venomous hostility to the religious establishment, *some* test is necessary, seems incontrovertible, if it be the business of the legislature to preserve the public peace.

To this it will be replied, That the public peace in Scotland is preserved without a test, and that therefore a test cannot be necessary in England. This is plausible, but not conclusive. For forty years after the Revolution, there was in Scotland no denomination of Christians but those of the Presbyterian church, established by law, the Protestant Episcopalians, whose church had been established prior to that event, and the adherents to the church of Rome. The Episcopalians and Papists were effectually excluded from every office in which they could injure the ecclesiastical establishment, by the several restrictions under which they were laid, on account of their attachment, real or supposed, to the abdicated family of Stuart. The penal laws operated upon them more powerfully than a religious test. It is to be observed too, that in the church of Scotland, though her clergy are better provided for than any other parochial clergy perhaps in Europe (A), there is nothing of that splendor and temporal power which in England excite envy to clamour against the establishment, under the pretence of maintaining the cause of religious liberty. Yet even in Scotland a religious test is occasionally exacted of civil officers. In the royal boroughs of that part of the united kingdom, no man can hold the office of a magistrate without previously swearing the burghers-oath (see SECEDER, n° 8.); and every instructor of youth, whether in schools or colleges, may be called upon to qualify himself for his office, by subscribing the established Confession of Faith. The burghers-oath is a more effectual test than that which is required of magistrates in England; for a man might with a safe conscience receive the sacrament of the Lord's Supper occasionally in a church, "at which he would not swear to abide and defend the same to his life's end." This test appears to us to be necessary in boroughs, where faction is commonly blended with fanaticism; and if those sectaries which, at their first appearance in 1732, were insignificant, if not contemptible, continue to multiply, and to imbibe principles much more pernicious than those which were held by their fathers, it may perhaps be found expedient to extend some test over the whole country.

We do not, however, by any means, wish to see the sacramental test introduced into Scotland. A test may be necessary to secure to the church all her rights and immunities; but to receive the sacrament can give her no such security, whilst it leads inevitably to the profanation of a sacred ordinance. A much better test would be, to require every man, before he be admitted to an executive office, to swear that in the discharge of it he will be careful to maintain all the rights and privileges of the church established by law. Such an oath no sensible and peaceable dissenter could refuse; for it would not bind him to communicate with the established church; and he cannot be ignorant that it belongs not to the executive government, but to the legislature, to determine what shall be the religion of the

state. On this account, we cannot help thinking that the members of the legislative body should be subjected to no religious test whatever, that they may be at freedom to reform the corruptions of the church, or to exchange one establishment for another, should they find such exchange expedient. If this reasoning be just, it will be difficult to vindicate that clause of 25 Car. II. and of 1 Geo. I. in which it is enacted, that no member shall vote or sit in either house of parliament till he hath, in the presence of the house, subscribed and repeated the declaration against transubstantiation, the invocation of saints, and the sacrifice of the mass. The church of Rome is indeed a very corrupt society; but if it be not for the purity of her doctrines and government that any church is established in preference to all others, why should that particular church be precluded from the possibility of obtaining a legal establishment in Great Britain, even though she were to become most acceptable to the majority of all ranks in the kingdom? The English Catholics have unquestionably greater reason to complain of this test, than either they or the dissenters have to complain of the law which requires every civil and military officer to receive the Lord's Supper in the established church.

TEST for Acids and Alkalis. See CHEMISTRY, p. 595, n° 1549.

TEST Liquors for Wines. See LEAD, p. 741. col. 2. and ARSENIC, n° 16.

TESTACEA, in the Linnæan system of natural history, the third order of vermes. This order comprehends all shell-fish arranged by Linnæus under 36 genera. Shell-fish are animals with a soft body, covered by or inclosed in a firm, hard, and as it were stony habitation, composed, according to their three separate orders, 1st, Of many parts which are ranged under the name of *multivalves*; 2d, Of two parts which are called *bivalves*; 3d, Of one part or piece only, which we call *univalves*. Those parts, pieces, or valves, are more or less moveable at the animal's pleasure. The animals included in these hard habitations have most of them the characters of one or other of the genera vermium, and might be reduced under the same genera with the mollusca: but as these characters are few, and the shells very numerous, and different in their form and structure, it will tend more to make this part of natural history easy, to arrange the subjects according to the distinctions of the shells themselves.

There is this farther consideration in favour of this arrangement, viz. that the animals themselves are rarely seen, and never can be preserved in cabinets; whereas the shells make a figure in them, and great numbers have been met with empty of the animal.

TESTACEOUS, in natural history, an epithet synonymous with **TESTACEA**.

In medicine, all preparations of shells, and substances of the like kind, are called *testaceous*. Such are powders of crabs claws and eyes, pearl, &c. Dr Quincy and others suppose the virtue of all testaceous medicines to be alike; that they seldom or never enter the lacteals, but that the chief of their action is in the first passages; in which, however,

(A) There are indeed many livings in the church of England, and probably in other churches, to which nothing in the church of Scotland can be compared in respect of emolument; but these rich benefices bear no proportion to the number of those which, in this age of unavoidable expence, cannot afford to the incumbents the means of decent subsistence as gentlemen. In the church of Scotland many livings amount to L. 200 each annually; and we have reason to hope, that when the present plan for augmenting the stipends of the clergy has been extended over Scotland, very few will be below L. 100; whilst in England the vicarages and small rectories, from which we have reason to believe that the incumbents reap not L. 80 a-year, greatly exceed in number all the livings in Scotland: Nay we doubt if there be not upwards of a thousand livings in England and Wales from which the rector or vicar derives not above L. 50 annually.

Testament ever, they are of great use in absorbing acidities. Hence they become of use in fevers, and especially in rectifying the many distempers in children, which generally owe their origin to such acidities.

Blackst.
Comment.
vol. ii.

TESTAMENT, or LAST WILL. Testaments both Justinian and Sir Edward Coke agree to be so called, because they are *testatio mentis*: an etymon which seems to favour too much of conceit; it being plainly a substantive derived from the verb *testari*, in like manner as *juramentum*, *incrementum*, and others, from other verbs. The definition of the old Roman lawyers is much better than their etymology; *voluntatis nostræ jussa sententia de eo, quod quis post mortem suam fieri velit*: which may be thus rendered into English, "the legal declaration of a man's intentions, which he wills to be performed after his death." It is called *sententia*, to denote the circumspection and prudence with which it is supposed to be made: it is *voluntatis nostræ sententia*, because its efficacy depends on its declaring the testator's intention, whence in English it is emphatically styled his *will*; it is *jussa sententia*; that is, drawn, attested, and published, with all due solemnities and forms of law: it is *de eo, quod quis post mortem suam fieri velit*, because a testament is of no force till after the death of the testator.

These testaments are divided into two sorts; written, and verbal or nuncupative: of which the former is committed to writing; the latter depends merely upon oral evidence, being declared by the testator in *extremis*, before a sufficient number of witnesses, and afterwards reduced to writing.

But as nuncupative wills and **CODICILS** (which were formerly more in use than at present when the art of writing is become more general) are liable to great impositions, and may occasion many perjuries, the statute of frauds, 29 Car. II. c. 3. enacts, 1. That no written will shall be revoked or altered by a subsequent nuncupative one, except the same be in the lifetime of the testator reduced to writing, and read over to him, and approved; and unless the same be proved to have been so done by the oaths of three witnesses at the least, who, by statute 4 & 5 Anne, c. 16. must be such as are admissible upon trials at common law. 2. That no nuncupative will shall in anywise be good, where the estate bequeathed exceeds 30l. unless proved by three such witnesses, present at the making thereof (the Roman law requiring seven), and unless they or some of them were specially required to bear witness thereto by the testator himself; and unless it was made in his last sickness, in his own habitation or dwelling-house, or where he had been previously resident ten days at the least, except he be surprised with sickness on a journey, or from home, and dies without returning to his dwelling. 3. That no nuncupative will shall be proved by the witnesses after six months from the making, unless it were put in writing within six days. Nor shall it be proved till fourteen days after the death of the testator, nor till process hath first issued to call in the widow, or next of kin, to contest it if they think proper. Thus hath the legislature provided against any fraud in setting up nuncupative wills, by so numerous a train of requisites, that the thing itself has fallen into disuse; and hardly ever heard of, but in the only instance where favour ought to be shown to it, when the testator is surprised by sudden and violent sickness. The testamentary words must be spoken with an intent to bequeath, not any loose idle discourse in his illness; for he must require the bystanders to bear witness of such his intention: the will must be made at home, or among his family or friends, unless by unavoidable accident, to prevent impositions from strangers: it must be in his last sickness; for if he recovers, he may alter his dispositions, and have time to make a writ-

ten will: it must not be proved at too long a distance from the testator's death, lest the words should escape the memory of the witnesses; nor yet too hastily and without notice, lest the family of the testator should be put to inconvenience or surprised.

As to written wills, they need not any witness of their publication. We speak not here of devises of lands, which are entirely another thing, a conveyance by statute, unknown to the feudal or common law, and not under the same jurisdiction as personal testaments. But a testament of chattels, written in the testator's own hand, though it has neither his name nor seal to it, nor witnesses present at its publication, is good; provided sufficient proof can be had that it is his hand-writing. And though written in another man's hand, and never signed by the testator, yet if proved to be according to his instructions and approved by him, it hath been held a good testament of the personal estate. Yet it is the safer and more prudent way, and leaves less in the breast of the ecclesiastical judge, if it be signed or sealed by the testator, and published in the presence of witnesses; which last was always required in the time of Bracton; or rather he in this respect has implicitly copied the rule of the civil law.

No testament is of any effect till after the death of the testator; *Nam Omne testamentum morte consummatum est, et voluntas testatoris est ambulatoria usque ad mortem*. And therefore, if there be many testaments, the last will overthrows all the former; but the republication of a former will revoke one of a later date, and establishes the first again.

Regularly, every person hath full power and liberty to make a will, that is not under some special prohibition by law or custom: which prohibitions are principally upon three accounts; for want of sufficient discretion; for want of sufficient liberty and free-will; and on account of criminal conduct.

1. In the first species are to be reckoned infants, under the age of 14 if males, and 12 if females; which is the rule of the civil law. For though some of our common lawyers have held that an infant of any age (even four years old) might make a testament, and others have denied that under 18 he is capable; yet as the ecclesiastical court is the judge of every testator's capacity, this case must be governed by the rules of the ecclesiastical law. So that no objection can be admitted to the will of an infant of 14, merely for want of age; but if the testator was not of sufficient discretion, whether at the age of 14 or 24, that will overthrow his testament. Madmen, or otherwise *non compos*, idiots or natural fools, persons grown childish by reason of old age or distemper, such as have their senses besotted with drunkenness,--all these are incapable, by reason of mental disability, to make any will so long as such disability lasts. To this class also may be referred such persons as are born deaf, blind, and dumb; who, as they have always wanted the common inlets of understanding, are incapable of having *animum testandi*, and their testaments are therefore void.

2. Such persons as are intestable for want of liberty or freedom of will, by the civil law are of various kinds; as prisoners, captives, and the like. But the law of England does not make such persons absolutely intestable; but only leaves it to the discretion of the court to judge upon the consideration of their particular circumstances of duress, whether or no such persons could be supposed to have *liberum animum testandi*. And, with regard to feme-coverts, our laws differ still more materially from the civil. Among the Romans there was no distinction; a married woman was as capable of bequeathing as a feme-sole. But with us a

Testament. married woman is not only utterly incapable of devising lands, being excepted out of the statute of wills, 34 & 35 Hen. VIII. c. 5. but also she is incapable of making a testament of chattels, without the licence of her husband. For all her personal chattels are absolutely his own; and he may dispose of her chattels real, or shall have them to himself if he survives her: it would be therefore extremely inconsistent to give her a power of defeating that provision of the law, by bequeathing those chattels to another. The queen-consort is an exception to this general rule, for she may dispose of her chattels by will, without the consent of her lord; and any feme-covert may make her will of goods which are in her possession *in auter droit*, as executrix or administratrix; for these can never be the property of the husband: and if she has any pin-money or separate maintenance, it is said she may dispose of her savings thereout by testament, without the controul of her husband. But if a feme-sole makes her will, and afterwards marries, such subsequent marriage is esteemed a revocation in law, and entirely vacates the will.

3. Persons incapable of making testaments on account of their criminal conduct, are in the first place all traitors and felons, from the time of conviction; for then their goods and chattels are no longer at their own disposal, but forfeited to the king. Neither can a *felo de se* make a will of goods and chattels, for they are forfeited by the act and manner of his death; but he may make a devise of his lands, for they are not subject to any forfeiture. Outlaws also, though it be but for debt, are incapable of making a will so long as the outlawry subsists, for their goods and chattels are forfeited during that time. As for persons guilty of other crimes, short of felony, who are by the civil law precluded from making testaments (as usurers, libellers, and others of a worse stamp), at the common law their testaments may be good. And in general the rule is, and has been so at least ever since Glanvil's time, *quod libera sit cujuscunque ultima voluntas*.

Testaments may be avoided three ways: 1. If made by a person labouring under any of the incapacities before-mentioned; 2. By making another testament of a later date; and, 3. By cancelling or revoking it. For though I make a last will and testament irrevocable in the strongest words, yet I am at liberty to revoke it; because my own act or words cannot alter the disposition of law, so as to make that irrevocable which is in its own nature revocable. For this, faith lord Bacon, would be for a man to deprive himself of that which, of all other things, is most incident to human condition; and that is, alteration or repentance. It hath also been held, that, without an express revocation, if a man, who hath made his will, afterwards marries and hath a child, this is a presumptive or implied revocation of his former will which he made in his state of celibacy. The Romans were also wont to lay aside testaments as being *inofficiosa*, deficient in natural duty, if they disinherited or totally passed by (without assigning a true and sufficient reason) any of the children of the testator. But if the child had any legacy, though ever so small, it was a proof that the testator had not lost his memory or his reason, which otherwise the law presumed; but was then supposed to have acted thus for some substantial cause: and in such case no *querela inofficiosi testamenti* was allowed. Hence probably has arisen that groundless vulgar error of the necessity of leaving the heir a failing, or some other express legacy, in order to disinherit him effectually; whereas the law of England makes no such wild supposition of forgetfulness or insanity; and therefore, though the heir or next of kin be totally omitted, it admits no *inofficiosa* to set aside such a testament.

TESTAMENT, in Scots law. See LAW, n^o clxxxi. 2. &c.

TESTAMENT (Old and New). See BIBLE and SCRIPTURE. Testament.

TESTATOR, the person who makes his will and testament. ||
Testudo.

TESTER, **TESTON**, the name of a coin struck in France by Louis XII. in 1513, and in Scotland in the time of Francis II. and Mary queen of Scotland, so called from the head of the king, which was engraved upon it. The silver it contained was 11 deniers 18 grains, its weight 7 deniers $11\frac{1}{4}$ grains, and its value 10 sols. The coinage of it was prohibited by Henry III. in 1575, when the value of it was augmented to 14 sols six deniers. The teston or tester among us was rated at 12d. in the reign of Henry VIII. and afterwards reduced to 6d.

TESTES, in anatomy, the testicles. See the next article.

TESTICLE (*testis*), a double part in animals of the male kind, serving for the office of generation.—See ANATOMY, n^o 107. They are called *testicles*, by diminution of *testes*, “witnesses;” as giving testimony of virility. The Greeks call them *didymi*, or “twins.”

In man and most animals, the testicles are exterior; in some, as fowls, interior. Some men have only one, ordinarily they have two; some have naturally had three; nay, anatomists assure us they have known four.

TESTIMONY. See LOGIC, n^o 29. and METAPHYSICS, n^o 135—138.

TESTIMONY, in law. See EVIDENCE.

TESTUDO, the TORTOISE, in zoology; a genus belonging to the class of *amphibia*, and order of *reptilia*. The body has a tail, and is defended with a bony or coriaceous covering. The mouth has naked mandibles without teeth. There are 33 species, of which the *midas* or common sea-turtle is the most remarkable. It is found in the island of Ascension and other places in the South Sea. The shell is so very strong that it can carry more than 600lbs. on its back, or as many men as can stand on it loaded. It digs round holes in the sand, in which it lays a vast number of eggs yearly, to the amount of 1000, it is said. It broods on them during the night. Its flesh is of a greenish colour, makes excellent food, and is the favourite dish of sailors as well as of epicures. It lives on cuttle and shell fish, and grows to a prodigious size, some having been found to weigh 480lbs.

The Americans find so good account in catching turtle, that they have made themselves very expert at it: they watch them from their nests on shore, in moon-light nights; and, before they reach the sea, turn them on their backs, and leave them till morning; when they are sure to find them, since they are utterly unable to recover their former posture: at other times they hunt them in boats, with a peculiar kind of spear, striking them with it through the shell; and as there is a cord fastened to the spear, they are taken much in the same manner as the whales.

Mr White, in his Natural History of Selborne, mentions a land-tortoise which had been kept for 30 years at Ringmer near Lewes. It retired under ground about the middle of November, and came forth again about the middle of April. At its first appearance in spring it showed little inclination for food; in the height of summer it became voracious; its appetite again diminished toward autumn, so that for the last six weeks it scarcely ate any thing at all. It lived chiefly on milky plants, such as lettuces, dandelions, and sow-thistles. Nothing surprised Mr White more than the extreme timidity it always showed for rain; for though it had a shell that would secure it against the wheel of a loaded cart, yet it discovered as much solicitude about rain as a fine lady dressed in her best attire, shuffling away on the first sprinklings.

Tetudo
||
Tetragonia.

lings, and running its head up in a corner. It not only slept during winter, but for a great part of the summer; for it went to bed in the longer days at four in the morning, and often did not stir in the morning till it was late. There was one season usually about the beginning of June when its exertions were remarkable. It then rose by five in the morning, and walked on tip toe, traversing the garden, examining every wicket and interstice in the fences. The motives that led it to these rambles seemed to be of the amorous kind. Mr White says it was an excellent weather-glass; for whenever it walked upright and fed with great avidity in the morning, it rained before night. It showed great sagacity in discerning those who did it kind offices; for whenever the old lady who had fed it for 30 years came in sight, it hobbled towards her with awkward alacrity.

TESTUDO, in antiquity, was particularly used among the poets, &c. for the ancient lyre; because it was originally made by its inventor Mercury, of the black or hollow of the testudo aquatica, or sea-tortoise, which he accidentally found on the banks of the river Nile. See LYRE.

TESTUDO, in the military art of the ancients, was a kind of cover or screen which the soldiers, *e. gr.* a whole company, made themselves of their bucklers, by holding them up over their heads, and standing close to each other. This expedient served to shelter them from darts, stones, &c. thrown upon them, especially those thrown from above, when they went to the assault.

TESTUDO, was also a kind of large wooden tower which moved on several wheels, and was covered with bullock hides, serving to shelter the soldiers when they approached the walls to mine them, or to batter them with rams. It was called *testudo*, from the strength of its roof, which covered the workmen as the shell does the tortoise.

TETANUS, a dreadful spasmodic disorder, in which the whole body becomes rigid and inflexible. It most commonly proves mortal. See MEDICINE, n° 279.

TETHYS, a genus of insects belonging to the class of *vermes*, and order of *mollusca*. The body is oblong, fleshy, and without feet; the mouth consists of a cylindrical proboscis under the duplicature of a lip; and there are two foramina at the left side of the neck. The species are two, both inhabitants of the ocean.

TETRACERA, in botany; a genus of plants belonging to the class of *polyandria*, and order of *tetragynia*, and in the natural system ranging under the doubtful. The calyx is hexaphyllous, and the capsules four. There is only one species, the volubilis.

TETRADYNAMIA, (*τεσσαρις* "four," and *δυναμις* "power"), four powers; the name of the 15th class in Linnæus's Sexual System, consisting of plants with hermaphrodite flowers, having six stamina, four of which are long, and two short; it corresponds to the *siliquosæ* of Ray, and *cruciformes* of Tournefort. All the species belonging to this class are distinguished by cruciform flowers. It comprehends two orders, *gymnospermia*, those plants which have naked seeds, being four in number, (except *phryma* which is monospermous); and *angiospermia*, which contains those plants the seeds of which are inclosed in a capsule. See BOTANY, p. 430.

TETRAGONIA, in botany; a genus of plants belonging to the class of *icosandria*, and order of *monogynia*; and in the natural system ranging under the 13th order, *succulenta*. The calyx is divided into three, four, or five parts. There is no corolla; the drupe is beneath, and the nut three or eight-celled. There are seven species; the *puticosa*, *decumbens*, *herbacea*, *echinata*, *expansa*, *crystallina*, and the *japonica*.

TETRAGRAMMATON, *τετραγράμματον*, a denomination given by the Greeks to the Hebrew name of God *יהוה*, "*Jehova*," because in the Hebrew it consists of four letters.

Tetragram-
maton
||
Tetrao.

TETRAGYNIA, (*τεσσαρις* "four," and *γυνή* "a woman"); the name of an order, or secondary division in the 4th, 5th, 6th, 8th, and 13th classes in the Sexual System; consisting of plants which, to the classic character, whatever it is, add the circumstance of having four styles or female organs. Herb-paris and grais of Parnassus furnish examples.

TETRANDRIA, (*τεσσαρις* "four," and *ανηρ* "a man or husband"); the name of the fourth class in Linnæus's Sexual System, consisting of plants with hermaphrodite flowers, which have four stamina or male organs that are of equal length. In this last circumstance consists the main difference, according to Linnæus, between the plants of the class in question and those of the 14th class *didynamia*, in which the four stamina are of unequal length, two of them being long, and two short.—The orders of this numerous class are three, founded upon the number of styles or female organs. Scabious, teazel, barren-wort, the starry plants of Ray, and the greater number of genera in this class, have one style; dodder and hypecoum have two; holly and a few others have four.

TETRAO, in ornithology; a genus of birds belonging to the order of *gallinæ*, and is thus characterized by Linnæus: There is a spot near the eyes naked or papillose, or covered, though more rarely, with feathers. Gmelin has enumerated about 66 species. The genus *tetrao* comprehended both the grouse, partridge, and quail; but Dr Latham, with great judgment and propriety, has made two genera of them, under the names of *tetrao*, comprehending the grouse; and *perdix*, comprehending the partridge and quail. Dr Latham thus distinguishes the genus *tetrao*: The bill is like a crooked cone, with a naked scarlet skin above each eye, and the feet feathered to the toes. The *perdix* he characterizes by a bill convex, strong, and short; the nostrils are covered above with a callous prominent rim; the orbits are papillose; the feet naked, and most of the species are furnished with spurs. He reckons 20 species under the *tetrao*, and 48 under the *perdix*. As we highly approve of this new arrangement of Dr Latham, we are disposed to follow it; but as a reference has been made from *PERDIX* to this place, it is proper that we should also give some account of that genus.

I. TETRAO. Of this genus the following species are found in Britain: 1. The *urogallus*, or wood-cock, inhabits woody and mountainous countries; in particular, forests of pines, birch-trees, and junipers; feeding on the tops of the former and berries of the latter; the first often infects the flesh with such a taste as to render it scarcely eatable. In the spring it calls the females to its haunts with a loud and shrill voice; and is at that time so very inattentive to its safety, as to be very easily shot. It stands perched on a tree, and descends to the females on their first appearance. They lay from 8 to 16 eggs; eight at the first, and more as they advance in age.

This bird is common to Scandinavia, Germany, France, and several parts of the Alps.—It is found in no other part of Great Britain than the Highlands of Scotland, north of Inverness; and is very rare even in those parts. It is there known by the name of *capercalzie*, *auer-calzie*, and in the old law-books *caperkally*; the last signifying the horse of the woods: this species being, in comparison of others of the genus, pre-eminently large.

The length of the male is two feet nine inches; its weight sometimes 14 pounds. The female is much less, the

Tetrao.

the length being only 26 inches. The sexes differ also greatly in colours. The bill of the male is of a pale yellow; the head, neck, and back, are elegantly marked, slender lines of grey and black running transversely. The upper part of the breast is of a rich glossy green; the rest of the breast and the belly black, mixed with some white feathers; the sides are marked like the neck; the coverts of the wings crossed with undulated lines of black and reddish brown; the exterior webs of the greater quill feathers are black: the tail consists of 18 feathers, the middle of which is the longest; these are black, marked on each side with a few white spots. The legs are very strong, and covered with brown feathers; the edges of the toes are pectinated. — Of the female, the bill is dusky; the throat red; the head, neck, and back, are marked with transverse bars of red and black: the breast has some white spots on it, and the lower part is of a plain orange colour: the belly is barred with pale orange and black; the tips of the feathers are white. The tail is of a deep rust-colour barred with black, tipped with white, and consists of 16 feathers.

2. The *tetrax*, black grouse, or black cock, like the former species, is fond of woody and mountainous situations; feeding on bilberries and other mountain fruits, and in the winter on the tops of the heath. In the summer they frequently descend from the hills to feed on corn. They never pair: but in the spring the male gets upon some eminence, crows and claps his wings; on which signal all the females within hearing resort to him. The hen lays seldom more than six or seven eggs. When the female is obliged, during the time of incubation, to leave her eggs in quest of food, she covers them up so artfully with moss or dry leaves, that it is very difficult to discover them. On this occasion she is extremely tame and tranquil, however wild and timorous at other times. She often keeps to her nest, though strangers attempt to drag her away. As soon as the young ones are hatched, they are seen running with extreme agility after the mother, though sometimes they are not entirely disengaged from the shell. The hen leads them forwards for the first time into the woods, to show them ant's eggs and the wild mountain-berries, which, while young, are their only food. As they grow older their appetites grow stronger, and they then feed upon the tops of heather and the cones of the pine-tree. In this manner they soon come to perfection: they are hardy birds, their food lies every where before them, and it would seem that they should increase in great abundance. But this is not the case; their numbers are thinned by rapacious birds and beasts of every kind, and still more by their own salacious contests. — As soon as the hatching is over, which the female performs in the manner of an hen, the whole brood follows the mother for about a month or two; at the end of which the young males entirely forsake her, and keep in great harmony together till the beginning of spring. At this season they begin for the first time to feel the amorous passions; and then adieu to all their former friendships! They begin to consider each other as rivals; and the rage of concupiscence quite extinguishes the spirit of society. They fight each other like game-cocks; and at that time are so inattentive to their own safety, that it often happens that two or three of them are killed at a shot. It is probable, that in these contests the bird which comes off victorious takes possession of the female seraglio, as it is certain they have no faithful attachments.

An old black cock is in length 22 inches, and weighs near four pounds. The bill is dusky; and the plumage of the whole body black, glossed over the neck and rump with a shining blue. The coverts of the wings are of a dusky

brown; the inner coverts white; the thighs and legs are covered with dark brown feathers; the toes resemble those of the former species. The tail consists of 16 black feathers, and is much forked; the exterior feathers bend greatly outwards, and their ends seem as if cut off. — The female weighs only two pounds; and its length is one foot six inches. The head and neck are marked with alternate bars of dull red and black; the breast with dusky black and white; but the last predominates. The back, coverts of the wings, and tail, are of the same colours as the neck, but the red is deeper. The tail is slightly forked; it consists of 18 feathers variegated with red and black. The feathers under the tail are white, marked with a few bars of black and orange. This bird hatches its young late in the summer. It lays from six to eight eggs, of a dull yellowish white colour, marked with numbers of very small ferruginous specks; and towards the smaller end with some blotches of the same hue.

3. The *scoticus*, red game, or moor-fowl, is peculiar to the British islands. The male weighs about 19 ounces; and is in length 15½ inches. The bill is black; the irides hazel-coloured. The throat is red. The plumage on the head and neck is of a light tawny red; each feather is marked with several transverse bars of black. The back and scapular feathers are of a deeper red; and on the middle of each feather is a large black spot; the breast and belly are of a dull purplish brown, crossed with numerous narrow dusky lines; the quill-feathers are dusky; the tail consists of 16 feathers of an equal length, all of them (except the four middlemost) are black, and the middle feathers are barred with red: the thighs are of a pale red, barred obscurely with black; the legs and feet clothed to the very claws with thick soft white feathers. The claws are whitish, very broad and strong. The female weighs only 15 ounces. — The colours in general are duller than those of the male: the breast and belly are spotted with white; and the tips of some of the coverts of the wings are of the same colour. — These birds pair in the spring, and lay from six to ten eggs. The young brood follow the hen the whole summer; in the winter they join in flocks of 40 or 50, and become remarkably shy and wild; they always keep on the tops of the hills, are scarce ever found on the sides, and never descend into the valleys. Their food is the mountain-berries and tops of the heath.

4. The *lagopus*, white game or ptarmigan, is 15 inches in length, and weighs 19 ounces. Its plumage is of a pale brown or ash colour, elegantly crossed or mottled with small dusky spots and minute bars; the head and neck with broad bars of black, rust colour, and white: the belly and wings are white, but the shafts of the greater quill-feathers black. In the male, the grey colour predominates, except on the head and neck, where there is a great mixture of red, with bars of white. The females and young birds have a great deal of rust colour in them. The tail consists of 16 feathers; the two middle of which are ash-coloured, mottled with black, and tipped with white; the two next black, slightly marked with white at their ends, the rest wholly black: the feathers incumbent on the tail are white, and almost entirely cover it.

Ptarmigans are found in these kingdoms only on the summits of the highest hills of the Highlands of Scotland, of the Hebrides, and Orkneys; and a few still inhabit the lofty hills near Keswick in Cumberland as well as the mountains of Wales. They live amidst the rocks, perching on the grey stones, the general colour of the strata in those exalted situations. They are very silly birds; so tame as to bear driving like poultry; and, if provoked to rise, take very short flights, making a great circuit like pigeons. Like

Tetrao.

Tetrao.

Tetrao.

Like the grouse, they keep in small packs; but never, like those birds, take shelter in the heath, but beneath loose stones. To the taste they scarce differ from a grouse.

These birds are called by Pliny *lagopi*, their feet being clothed with feathers to the claws, as the hare's are with fur; the nails are long, broad, and hollow. The first circumstance guards them from the rigour of the winter; the latter enables them to form a lodge under the snow, where they lie in heaps to protect themselves from the cold. The feet of the grouse are clothed in the same manner; but those of the two first species here described, which perch upon trees, are naked, the legs only being feathered, not being in want of such a protection.

II. *PERDIX*, comprehends both the partridge and quail.

The common partridge is so well known that a description of it is unnecessary, and we have not room to describe the foreign species. We refer those who wish complete information to the accurate and valuable *System of Ornithology* published by Dr Latham. The scientific ornithologist will find much satisfaction in his *Index Ornithologus*, published in 2 vols 4to; and he who wishes to be acquainted with the nature and dispositions of birds, will read his *Synopsis* with pleasure, published in 7 vols 4to.

The following general account of the partridge will suffice: "These birds (says Willughby) hold the principal place in the feasts and entertainments of princes; without which their feasts are esteemed ignoble, vulgar, and of no account. The Frenchmen do so highly value, and are so fond of the partridge, that if they be wanting, they utterly slight and despise the best spread tables; as if there could be no feast without them." But however this might be in the times of our historian, the partridge is now too common in France to be considered as a delicacy; and this, as well as every other simple dish, is exploded for luxuries of a more compound invention. In England, where the partridge is much scarcer, and a great deal dearer, it is still a favourite delicacy at the tables of the rich; and the desire of keeping it to themselves has induced them to make laws for its preservation, no way harmonising with the general spirit of English legislation.

The partridge seems to be a bird well known all over the world, as it is found in every country and in every climate; as well in the frozen regions about the pole, as the torrid tracks under the equator. It even seems to adapt itself to the nature of the climate where it resides. In Greenland, the partridge, which is brown in summer, as soon as the icy winter sets in, begins to take a covering suited to the season: it is then clothed with a warm down beneath; and its outward plumage assumes the colour of the snow among which it seeks its food. Thus it is doubly fitted for the place, by the warmth and the colour of its plumage; the one to defend it from the cold, the other to prevent its being noticed by the enemy. Those of Barakonda, on the other hand, are longer legged, much swifter of foot, and choose the highest rocks and precipices to reside in.—They all, however, agree in one character, of being immoderately addicted to venery; and, as some writers affirm, often to an unnatural degree. It is certain, the male will pursue the hen even to her nest; and will break her eggs rather than not indulge his inclinations. Though the young ones have kept together in flocks during the winter, when they begin to pair in spring their society disperses; and combats, very terrible with respect to each other, ensue. Their manners in other circumstances resemble all those of poultry in general; but their cunning and instinct seem superior to those of the larger kinds. Perhaps, as they live in the very neighbourhood of their enemies, they have more frequent occasion to put their little arts in practice, and learn by habit the means of eva-

sion or safety. Whenever therefore a dog or other formidable animal approaches their nest, the female uses every means to draw him away. She keeps just before him, pretends to be incapable of flying, just hops up, and then falls down before him, but never goes off so far as to discourage her pursuer. At length, when she has drawn him entirely away from her secret treasure, she at once takes wing, and fairly leaves him to gaze after her in despair. After the danger is over, and the dog withdrawn, she then calls her young, who assemble at once at her cry, and follow where she leads them. There are generally from 10 to 15 in a covey; and, if unmolested, they live from 15 to 17 years. There are several methods of taking them, as is well known; that by which they are taken in a net with a setting dog is the most pleasant, as well as the most secure. The dog, as every body knows, is trained to this exercise by a long course of education: by blows and caresses he is taught to lie down at the word of command; a partridge is shown him, and he is then ordered to lie down; he is brought into the field, and when the sportsman perceives where the covey lies, he orders his dog to crouch: at length the dog, from habit, crouches wherever he approaches a covey; and this is the signal which the sportsman receives for unfolding and covering the birds with his net. A covey thus caught is sometimes fed in a place proper for their reception; but they can never be thoroughly tamed like our domestic poultry. See *PARTRIDGE* and *SHOOTING*.

2. The *colurnix*, or common quail, is not above half the size of the partridge. The feathers of the head are black, edged with rusty brown; the breast is of a pale yellowish red, spotted with black; the feathers on the back are marked with lines of pale yellow, and the legs are of a pale hue. Except in the colours thus described, and the size, it every way resembles a partridge in shape, and, except that it is a bird of passage, it is like all others of the poultry kind in its habits and nature.

The quail seems to spread entirely throughout the old world, but does inhabit the new; is seen from the Cape of Good Hope quite to Iceland, and is said to be found in Falkland Isles; also in New Zealand, throughout Russia, Tartary, and China*; and in short is mentioned by so many * See *For-* travellers, and in so many places, that we may almost call it an *ster's Obs. p.* inhabitant of all. It is observed to shift quarters according 199. to the season, coming northward in spring, and departing south in autumn, and in vast flocks, like other migrating birds. Twice in a year it comes in such vast quantities into Capri, that the bishop of the island draws the chief part of his revenue from them; hence he is called the *quail Bishop*. But this does not stand alone; almost all the islands *Latham's* in the Archipelago, on the opposite coasts, are at times *Synopsis* covered with these birds, and some of them obtain a name *vol iv.* from this circumstance. On the west coast of the kingdom of Naples, within the space of four or five miles, an hundred thousand have been taken in a day, which have been sold for eight livres *per* hundred to dealers who carry them for sale to Rome. Great quantities also sometimes alight in spring on the coasts of Provence, especially in the diocese of the bishop of Frejus, which is near the sea, and appear, at their first landing, so much fatigued that they are often taken by the hand. These circumstances then leave not a doubt of their being the same kind of birds which the divine hand of providence thought right to direct in such quantities as to cover the camp of the murmuring Israelites.

"In the autumn, great quantities are frequently imported into England from France for the table; which we have frequently seen (says Dr Latham) on their passage to London by the stage-coaches, about an hundred in a large square box, divided into five or six partitions one above another, just high enough

Tetrao
||
Tetuan.

enough to admit of the quails standing upright; these boxes have wires on the fore part, and each partition furnished with a little trough for food; and I have been told, says our author, they may be conveyed thus to great distances without difficulty."

With us they may be said not to be plenty at any time. They breed with us, and the major part migrate south in autumn; the rest only shift their quarters, as they have been met with on the coasts of Essex, and in Hampshire, in the winter-season, retiring there in October.

It feeds like the partridge, and like that bird makes no nest, except a few dry leaves or stalks scraped together may be called so, and sometimes an hollow on the bare ground suffices. In this the female lays her eggs to the number of six or seven, of a whitish colour, marked with irregular rust-coloured spots: the young follow the mother as soon as hatched, like young partridges. They have but one brood in a year.

Quail-fighting was a favourite amusement among the Athenians. They abstained from the flesh of this bird, deeming it unwholesome, as supposing that it fed upon the white hellebore: but they reared great numbers of them for the pleasure of seeing them fight; and staked sums of money, as we do with regard to cocks, upon the success of the combat. Fashion, however, has at present changed with regard to this bird: we take no pleasure in its courage, but its flesh is considered as a very great delicacy.—Quails are easily caught by a call: the fowler early in the morning having spread his net, hides himself under it among the corn; he then imitates the voice of the female with his quail-pipe, which the cock hearing, approaches with the utmost assiduity; when he has got under the net, the fowler then discovers himself, and terrifies the quail, who attempting to get away, entangles himself the more in the net, and is taken.

TETRODON, in ichthyology; a genus of fishes arranged by Linnæus under the class of *amphibia*, and order of *nantes*; but placed by Gmelin under the class of *pisces*, and order of *branchiostegi*. The jaws are bony, stretched out, and cloven at the point; the aperture of the gills is linear; the body is muricated beneath, and there are no ventral fins. There are 13 species; of which the most remarkable is the *lineatus*, called by Mr Hasselquist *fabaka*, which is the Egyptian and Arabic name. It has of late been found in the Nile about Cairo, but was never known in former times. It is said to grow to a prodigious size. When just caught, it pricks the skin if it is taken in the bare hands, and produces small pustules in the same manner as nettles. The flesh is poisonous. Mr Forster confirms the account of the poisonous nature of a species of tetrodon, in his account of New Caledonia.

TETRARCH, a prince who holds and governs a fourth part of a kingdom. Such originally was the import of the title *tetrarch*; but it was afterwards applied to any petty king or sovereign; and became synonymous with *ethnarch*, as appears from the following considerations: 1. That Pliny makes mention of six tetrarchies within the city of Decapolis. 2. That Herod's kingdom was only divided into three parts, which yet were called *tetrarchies*, and the sovereigns thereof, Luke iii. 1. *tetrarchs*. 3. Josephus tells us, that, after the battle of Philippi, Antony, going into Syria, constituted Herod *tetrarch*; and on medals the same Herod is called *ethnarch*.

TETRASTYLE, in the ancient architecture, a building, and particularly a temple, with four columns in its front.

TETUAN, an ancient and pleasant town of Africa, in the kingdom of Fez, and in the province of Habata. It

is pretty well built, and the inhabitants are about 15,000 in number, who call themselves *Andalusians*, and almost all speak Spanish; but they are great pirates. Some say there are 30,000 Moorish inhabitants, and 5000 Jews. W. Long. 5. 26. N. Lat. 35. 27.

TEUCRIUM, GERMANDER, in botany: A genus of plants belonging to the class of *didynamia*, and order of *gymnospermia*; and in the natural system ranging under the 42d order, *Verticillata*. The corolla has no upper lip, is divided into two parts beyond the base, and is divaricated where the stamina issue out. There are 30 species; of which the *scorodonia*, *scordium*, and *chamædrys*, are natives of Great Britain.

1. The *scorodonia*, wood-sage, or germander, is distinguished by leaves which are heart-shaped, serrated, and petiolated; by racemi, which are lateral and ranged in one row; and by an erect stem. The flowers are straw-coloured, and the filaments red. The plant has a bitter taste, and smells like hops with a little mixture of garlic. It is used in brewing in the isle of Jersey instead of hops. 2. The *scordium*, or common water-germander, hath creeping perennial roots, sending up many square, procumbent, or trailing stalks, branching diffusely; oblong, indented, serrated, close-fitting, opposite leaves; and small reddish flowers, generally two together, from the sides of the stalks and branches, in July and August. This plant was formerly considered as medicinal, but has now fallen into disuse. It grows naturally in marshy places, in the isle of Ely and other parts of England, and most parts of Europe; and is sometimes admitted into gardens, in moist places, for variety, and as a medical plant. 3. The *chamædrys*, or smaller creeping germander, hath fibrous, very creeping, spreading roots; many four-cornered, very branchy, trailing stalks, near a foot long; oval, cuneiform, cut, crenated leaves on short footstalks; and reddish flowers, growing almost in a verticillus, or whorls, round the stalk, three on each peduncle; appearing in June and July.

TEUTHIS, in ichthyology, a genus of fishes belonging to the order of *abdominales*. The head is somewhat truncated on the forepart; the branchial membrane has five rays; the teeth equal, rigid near each other, forming a regular series. There are two species, the *hepatus* and *java*.

TEUTONES, or TEUTONI, (anc. geog.) a people always by historians joined with the Cimbri; both seated, according to Mela, beyond the Elbe, on the Sinus Codanus, or Baltic; and there, it is supposed, lay the country of the Teutones, now *Ditmarsh*; diversity of dialects producing the different terms *Teut*, *Tut*, *Dit*, *Tid*, and *Thod*, which in the ancient German language signified *people*. Of these Teutones, Virgil is to be understood in the epithet *Teutonicus*, an appellation which more lately came to be applied to the Germans in general, and later still the appellation *Alemanni*.

The Teutones, in conjunction with the Cimbri and Ambrones, made war on the Romans, and marched towards Italy in the year 101 B. C. We are told, that the Teutones alone were so numerous, that they were six whole days without intermission in passing by the Roman camp. In Transalpine Gaul they engaged the Roman consul Marius; but were defeated with incredible slaughter; 100,000 of them, according to the lowest calculations, being killed on the spot. According to others, the number of those killed and taken prisoners amounted to 290,000. The inhabitants of the neighbouring country made fences for vineyards of their bones. Their king Teutobochus, said to be a monstrous giant, was taken prisoner and carried to Rome. See the article GIANT.

TEUTONIC, something belonging to the Teutones. The

Josephus's
Antiq. B.
xiv. c. 23.



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